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THE EFFECTS OF VERBAL CUES ON TRANSFER OF TRAINING.

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FOUR EXPERIMENTS WERE CONDUCTED TO STUDY EFFECTS OF VERBAL CUES ON LEARNING RETENTION AND TRANSFER. CUES INCLUDED RULES AND ANSWERS PROVIDED BEFORE RESPONDING AND RULES AND ANSWERS PROVIDED AS FEEDBACK. THE FIRST EXPERIMENT INVOLVED SECONDARY SCHOOL STUDENTS WHO USED RULE AND ANSWER PROMPTS. THE SECOND EXPERIMENT CONSIDERED PROMPTS AND FEEDBACK. THE THIRD AND FOURTH EXPERIMENTS WERE PARALLEL WITH THE FIRST TWO BUT INVOLVED COLLEGE STUDENTS. MOTIVATION AND THE EFFECTIVITY OF TREATMENT WERE STUDIED IN ALL EXPERIMENTS. THE DEPENDENT VARIABLES WERE SCORES ON A TEST WHICH REQUIRED DECODING OF CRYPTOGRAMS AND ANOTHER REQUIRING DERIVATION OF DECODING RULES. NO SUBJECT IN EITHER GROUP TOOK BOTH TESTS. THE HYPOTHESIS THAT SPECIFICATION OF RULES AND ANSWERS WILL INCREASE PERFORMANCE AND PERFORMANCE TRANSFER WAS SUPPORTED BY THE FIRST EXPERIMENT AND PARTIALLY BY THE SECOND EXPERIMENT. ANSWERS USED AS FEEDBACK DID NOT PRODUCE INCREASED PERFORMANCE. THE HYPOTHESIS THAT RULE FEEDBACK WOULD BE INFERIOR TO ANSWER FEEDBACK WAS NOT SUPPORTED. FEEDBACK WHICH INCLUDED CORRECT ANSWERS INCREASED LEARNING ONLY IF THE ANSWERS WERE NOT PROVIDED AS PROMPTS. RESULTS OF THE THIRD AND FOURTH EXPERIMENTS SUPPORTED RESULTS OF EXPERIMENTS ONE AND TWO. (WN)

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ON TRANSFER OF TRAINING**

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M. C. WITTROCK

Title VII Project Number 1107
National Defense Education Act of 1958
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**UNIVERSITY OF CALIFORNIA, LOS ANGELES
LOS ANGELES, CALIFORNIA**

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To my wife, Nancy, and to my children,
Steve, Cathy, and Becky, who didn't see Daddy
as much as they should have last year.

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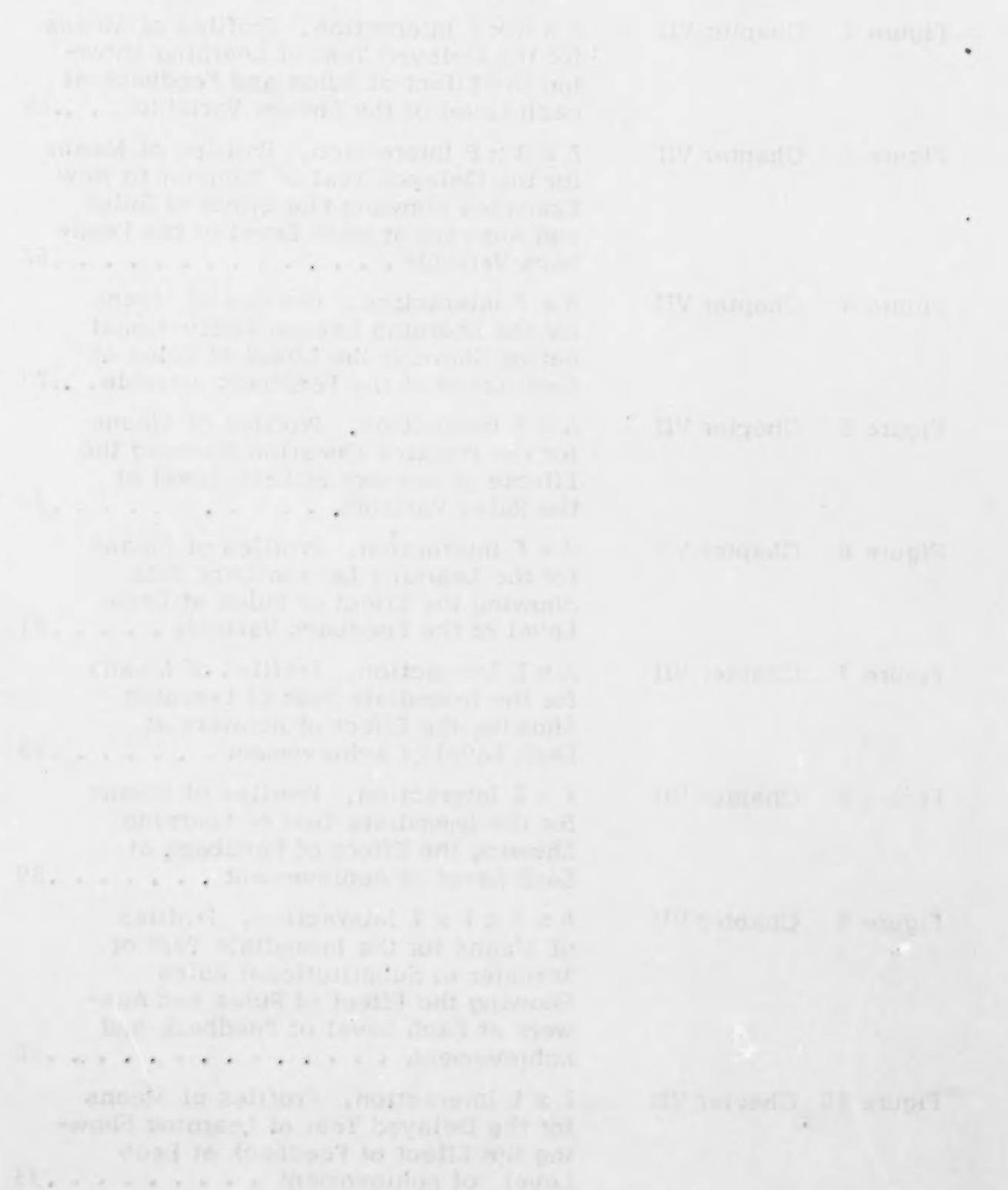
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PREFACE

The research which is reported in the following pages is the result of the time and effort of many people. I especially want to thank Dr. Paul Twelker. He participated in the design of the study. Almost singlehandedly, he collected the data and performed the statistical analyses. But most of all I want to thank the hundreds of high school students who were the subjects of the experiments.

Dr. Joseph Murnin, of the U.S. Office of Education, offered many helpful ideas during all the major parts of the study. His letters, telegrams and several visits were all greatly appreciated.

Miss Sheryl Berman was the secretary who typed the manuscripts and the stencils. She was patient with the many revisions, and competent with her many responsibilities.

I am greatly indebted to the directors of research of the school districts who provided students for the experiment: Dr. Vincent Alexander, Culver City Unified School District, Dr. Julius Stier, Santa Monica Unified School District, Dr. Gerwin C. Neher, Los Angeles Unified School District, and Dr. Quentin Brian, Inglewood Unified School District. They cooperated with the experiment, even when it disrupted their busy schedules.

Thanks are due to the following people who made the study possible: at the Culver City High School, Mr. Paul Adamson, Principal, Mr. Robert Johnson, Mr. Harold Burke, Mr. George Kirkpatrick, Mr. Edward Helwick, and Mrs. Barbara Feldman, Teachers.

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I want to thank the UCLA Campus Computing Facility for the use of its IBM 7094 electronic computer. The research reported herein was supported by a Title VII grant from the U.S. Office of Education. With-

out the cooperation of every individual and agency mentioned, the study could not have been completed.

The project began on June 20, 1963 and was completed February 18, 1965. In the original proposal, only the first of these two experiments was anticipated. However, after the first experiment was completed, the results were quite gratifying and encouraged us to examine our variables in more detail.

Experiment two is the result. Thanks to the U.S. Office of Education, and to Dr. Joseph Murnin, we were given additional time and money to perform this second experiment. Although these dependent variables required an exceptionally great amount of human and computer time and energy to analyze (see Chapter VII) I am delighted that they were included in the study. We have an understanding of the effects of the verbal cues upon learning, retention, and transfer of high school students which we could not have had without these dependent variables.

M.C. Wittrock

University of California, Los Angeles

February 18, 1965

CHAPTER I

THE PROBLEM

Introduction

Teachers, researchers, and programmers have often asked questions similar to the following one: "How much direction should one give to students to help them learn?" This apparently simple question presents a most complicated problem for educational research. There are many types and amounts of direction. A teacher can present a rule and follow the rule with an unanswered problem. He can then ask the student to work the problem. On the other hand, he can present the student with two or more unanswered problems and ask the student to derive a rule that is common to these problems. He might then tell the students that their answers are either correct or incorrect or might give them the correct rules and answers.

Independent Variables

In the above example several independent variables are obvious. The cues can be presented before a student responds (prompts) or after a student responds (feedback). The cues which are given to the student can also be classified into rules, examples, and answers to the examples. The rules, examples, and answers can be presented in several orders. For example, a rule could be followed by one or more examples (which may or may not include the correct answers). Conversely, one or more examples could be followed by a rule. These variables in prompting may interact with the feedback which is given. For example, if rules and answers are given before a student works a problem, it may be superfluous to provide him with feedback that again mentions the rule and answers. The present experiment varied prompts and feedback as independent variables.

Dependent Variables

Any answer to the above-mentioned question not only depends upon what is meant by direction as an independent variable, but certainly must also depend upon what is meant by learning as a dependent variable. If the objective is to teach a few, arbitrary associations, the information the teacher provides a student may be different from the information which may produce retention, transfer, and savings. The information he presents may depend upon whether he wants to produce transfer

to other examples of previously learned rules or whether he wants to produce remote transfer--transfer to new concepts and rules. He may want students to solve problems on their own, to be creative, and even "to think."

If one turns to the research literature on direction in problem solving and learning, he finds, among some inconsistencies, that the dependent variables seem to influence the type of direction given to the learners (see Chapter II below). The ordinary dependent variables of an autoinstructional program are immediate recall and knowledge of facts. Programs are usually highly prompted and often present rules and answered examples. Although there is an idea in programmed instruction that rules should come before examples, this idea has been largely developed on faith rather than on data. Because most programs have been written with specific objectives in mind, one does not know what a program written for transfer would be like.

There is a definite need for more research that considers transfer and savings as bases for evaluation. These criteria seem appropriate to evaluate the development of concepts, because they present stimuli different from those presented during learning. The student is required to apply the previously learned knowledge to novel situations.

The studies on learning by discovery, which have not been conducted in a programmed-instruction context, seem to indicate that giving rules and also giving answered examples may not be the optimum situation for producing transfer, although this situation does produce the greatest amount of learning of a few arbitrary associations. These studies have not often used transfer as a criterion. Much of the research on mediated generalization and mediated discrimination has used some type of transfer criterion; e.g., reversal shifts and non-reversal shifts, to measure what has been learned. Unfortunately, not many of these studies have systematically varied verbal cues (such as rules and answers) which are of interest to educators. The studies on mediated generalization, some of which are mentioned in the next chapter, do indicate that transfer within a class can be produced by developing a cue which is distinctive for that class. Further, when a variety of classes of problems is repeatedly encountered,

a distinctiveness among classes may also be learned. There is then some theory and research which may be extrapolated to include the problem of the present study.

Operational Definition of Terms

The problem for the present study was to sample different types and amounts of direction and relate these to the dependent variables of learning, retention, and transfer. An important part of the study was the operational definition of these independent and dependent variables. The term "prompt" is defined as some type of verbal or symbolic cue which is given before the student makes a response and which facilitates and encourages the desired response from the learner (Cook, 1961). A prompt may be any verbal or physical cue, such as a "rule", an "answer", a rhyme, an underlined word, or a color cue. Feedback then is a cue which comes after the learner has responded.

Two kinds of prompts were varied in the present study: rules and answers. The term "rule" referred to the written verbalization of a principle or abstraction. The term "answer" referred to specific dechiphered sentences. Feedback consisted of knowledge of the correct response, and specified both the appropriate rule and the correct answer.

The dependent variables of the study were also operationally defined. Learning was sampled by a test which included only problems identical to those which a student had encountered during the lesson.

Retention was measured with problems identical to those used in the lesson one week earlier. Transfer to new examples was defined by several tests. One test included only unfamiliar transpositional problems which could be solved according to the rules which had been used to solve the problems presented during the lesson. Transfer to new rules was defined by two tests which presented unfamiliar problems that could be solved only by using rules not previously encountered. In all of the lessons, students were taught to solve only transpositional cryptograms (see below). They were never given substitutional cryptograms. One transfer test presented problems which could be solved with transpositional rules not previously studied. The second transfer

test presented problems which could be solved only by using rules for substitutional cryptograms.

A second set of transfer tests was used. These tests paralleled those mentioned in the above paragraph but gave to the students answered examples from which they had to derive rules. One-half of the subjects were given the problem-solving tests mentioned in the above paragraph. No subject took both types of tests.

Intervening Variables and Theory

The intervening variables must also be specified. Mediation theory hypothesizes mediating stimuli and responses (r-s) which intervene between initiating stimuli (S) and terminating responses (R). The operational model for this series (S-r-s-R) is often represented by the series (A-B-C), with the B term as the operational equivalent of the mediating response and the mediating stimulus. Each B term may be associated with more than one A term. Each B may also be associated with a specific response, or with several responses (C). In this case, the B term is the common mediating term for the several A terms or is the common "meaning" of these A terms, and is probably most important in concept learning studies, where there is a hierarchical arrangement of many stimuli to a common response.

The present study presents problems (A terms) which were not associated, before the experiment, with the rules (B terms). The subject must learn to associate the problems with the rules (As with Bs). However, it is assumed that the rules (Bs) have, in the history of the subjects, been associated with the terminating responses (Cs). In brief, by giving the subject a simple rule, e.g., reverse the order of the letters, one can bring to the problem a wealth of associations (Cs) simply because the B-C associations already exist in the learner's repertoire. After reinforced experience with several distinctive problems and several different rules, he may learn a mediated discrimination between rules and also a mediated generalization across those problems which are examples of a given rule. This, of course, depends upon the physical or mediated discriminability of the problems themselves. Given problems which are not readily discriminable, the learner probably samples from among all available rules until he finds the one which is correct.

The rules then are B terms which can be presented during learning as initiating stimuli (A terms). They should increase transfer to new examples of these same rules. The answers are probably best thought of as C terms, which are presented as independent variables during learning. Each C term may not produce transfer because it short circuits the explicit verbalization of the B term.

The reader must not confuse stimulus and response terms during performance with independent and dependent variables during learning. The answer variable, in this study, is an independent variable although it probably corresponds to a C term in the mediation paradigm. When he is given an answer, a learner must induce a rule if any is to be learned. The rule or B term is not necessarily apparent in a condition which does not specify rules during learning. It is on the tests that the A, B, and C terms are used respectively to describe initiating stimuli, intervening variables and terminating responses.

Subject Matter and Subjects

Another important problem encountered in this study was the selection of subject matter appropriate to study the effects of direction. Cryptography is a subject matter which allows the experimenter to vary rules, answers, and feedback. The rudiments of cryptography are known to very few secondary school students. At the same time, these rudiments can be taught in a brief period of time. For these reasons, transpositional and substitutional cryptograms were chosen as the context for the study. Secondary school students were the subjects because the results of the study should apply to public school teaching.

Summary

In sum, the study was designed to determine, in a rigorous fashion, some of the effects upon learning, retention, and transfer produced by three types of verbal cues: rules, answers, and feedback. (Time, affectivity, and motivation were also measured.) As described in Chapter III below, we were much interested in any interactions that might exist between the two different types of prompts and feedback. But most important was the opportunity to find if a given procedure might produce an effect on initial learning but not necessarily on transfer or vice versa. That is, what differences might there be in

material which would produce an effect on one dependent variable (learning) when it was compared with material which obtained an effect on a different variable (transfer)? From our earlier work on transfer in problem solving, we hypothesized a primary effect for the rule variable and an interactional effect between the prompting and feedback variables. The details of these hypotheses are presented in Chapter III below.

The hypotheses were studied in two separate experiments, which were performed after four pilot studies were completed. Experiment I related two independent variables, rules and answers, to the dependent variables of transfer to new examples and transfer to substitutional rules. Experiment II studied the same two independent variables, but also manipulated feedback. In addition to the dependent variables sampled in Experiment I, learning, retention, and transfer to new transpositional rules were sampled in Experiment II.

The report is divided into eight chapters and an appendix. The problem, the related research, and the hypotheses are presented in Chapters I through III, respectively. The four pilot studies are presented in Chapter IV. Chapter V presents the method and results of the first experiment. Because the second experiment was rather lengthy and involved, it is described in two chapters. Chapters VI and VII present the method and results sections respectively for Experiment II. In both experiments, the dependent variables were sampled with two sets of tests. One involved the decoding of cryptograms. The second involved taking already decoded cryptograms and deriving a rule appropriate for their decoding. Chapter VIII discusses the findings of the study in relation to the specific hypotheses presented in Chapter III and in relation to the other issues raised in Chapter I. The Appendix includes some materials and tests used in the study and also tables which present the results of several analyses of covariance.

CHAPTER II

RELATED RESEARCH

The research reported below is divided into three major parts. First there is a section on mediation theory. Next is a section on empirical research which reports the effects of verbal mediators. The third and largest section of this chapter is on experimenter-supplied verbal cues. It is divided into parts which correspond to the independent variables of this study. That is, prompts, feedback, and prompts interacting with feedback are treated there.

Mediation Theory

A mediation paradigm was introduced and described in Chapter I above. The mediation hypothesis need not be described again here. For further details about the mediation hypothesis see Cofer and Foley (1942); Osgood (1953); Goss (1961); Dollard and Miller (1950); and Staats (1961). The mediation hypothesis seems appropriate for research on classroom learning, where concept formation and identification probably play an important part.

Verbal versus non-Verbal Mediators

Whether they are supplied by an experimenter or not, there is a great deal of research in experimental psychology which indicates that verbal mediators can facilitate learning under a variety of conditions. Most of the studies reported below have been done with young children. Birge (1941) found that young children who were taught one name for two different objects generalized across these objects more than children who were taught two different names for these two objects. Cantor (1955) found that distinctive labels for stimulus objects have a greater effect upon transfer than a condition which specified no distinctive names for the stimuli. Dietze (1955) found essentially the same thing. The kindergarten children who learned distinctive labels learned and transferred greater than did the children who learned similar labels for the similar stimuli.

Verbal labels may produce an "acquired distinctiveness of cues" which can help the children to discriminate and transfer. A number of experiments (Kendler and Kendler, 1956, 1959, 1961, 1962, and Kendler, Kendler, and Wells, 1960) indicate that when verbal labels

for concepts are learned, they can then function as verbal mediators. The Kendlers theorize that verbal mediators enable a child to make a reversal shift more readily than a non-reversal shift. For example, if the child had learned the label color, a reversal shift would mean that the correct answer was changed from one color to another. A non-reversal shift would involve his learning that a new label, size, must be substituted for the previously correct label of color. The non-reversal shift, where it is assumed that verbal mediators are not in operation, seems to be easier for infrahumans and children near or under the age of six. Most children aged six and older make reversal shifts easier than non-reversal shifts.

Norcross and Spiker (1957) have also found that verbal labels will affect transfer with young children. Murdock (1960) has also found that learning and transfer are increased by verbal responses and that the distinctive cues produce greater transfer than dissimilar cues.

There appears to be ample evidence to conclude that, verbal cues and labels can have great effects upon learning and transfer. Unfortunately, most of the above mentioned studies are not closely related to the problem of the present study. When one looks at the effects of verbal cues supplied by an experimenter there is not a complete agreement about the learning and transfer which results.

Verbal cues supplied by the experimenter

This third and last section is divided into three parts. The first part presents some studies on verbal cues presented before the subject responds (prompts). The second part is on the verbal cues presented after the subject responds (feedback); and the third and final part relates prompts to feedback.

Prompts. Maier (1930) found that providing a verbal cue ("Observe how easy the solution would be if you could only hang the pendulums from two nails from the ceiling") helped people to solve his double pendulum problem. Ewert and Lambert (1932) found that instructions increased the subjects ability to solve problems which involved moving circular cardboard discs from a given arrangement to a second specified arrangement. Irwin (1934) found that learning was best when a rule or

principle was rehearsed and its application was practiced. Now this finding is closely related to Hypotheses 1 and 2 of the present study. These hypotheses are explained in the following chapter. Both of the hypotheses assume that transfer to new examples of learned rules is best produced when the subject is given rules and is given an opportunity to practice the application of these rules.

In linguistics, Rubinstein and Aborn (1954) have found that giving rules which explain the formation of redundant sequences increases learning. The same type of effect has been found by Miller (1951); Fitts, Weinstein, Rappaport, Anderson, and Leonard (1956); and by Anderson and Leonard (1958). Shipstone (1960) found that verbal instructions help when the task is not overly difficult. It seems that rules and instructions enable the subject to extract information from examples.

There are many studies which appear in research on educational psychology under the title "learning by discovery". Although these studies do not always agree with the studies mentioned above on verbal mediators, they do vary prompts and their independent variables are closely related to those of the present study. Craig (1956) used college subjects and required two experimental groups to solve a series of verbal problems. The "directed" group was given a general statement of rules while the "independent" group was not given the rules. Knowledge of results was given to both groups. He showed that the group given the rules learned and retained more than the group which was not given the rules. However, his results indicated no dependable difference on a test of transfer to new rules. He concluded that the direction given by the experimenter gave the learner an adequate background of knowledge to direct his future discovery.

Kittell (1957) placed sixth grade students into three treatment groups. The "minimum" group received only the test items and the instructions that there was an underlying principle for each item. The "intermediate" group was given the same list of test items, as well as a verbal statement of the principle involved. The "maximum" group received the same stimuli as the other groups, but in addition, they were given the correct answers to the test items before they

responded. All three groups received knowledge of results through the use of punchboards. On the learning test, both the "intermediate" and "maximum" groups scored dependably higher than the "minimum" group. On tests of retention, transfer to new examples, and transfer to new principles, the "intermediate" group was reliably higher than both the other groups. Kittell concluded that presenting rules to learners enhances retention and transfer to learned principles and provides the background which promotes discovery of new principles.

Forgus and Schwartz (1957) taught college students a new alphabet by three methods. The "observer" group received the new alphabet and its English alphabet construction. The "participant" group was given the same list, but were told only that there was an underlying rule which they were to derive in writing. The "memorization" group was given the same symbols as the above groups, but in a rearranged order so subjects could not easily derive the rule. It was shown that the groups which either were given the rule or were required to derive the rule were superior on tests of retention, transfer to new examples, and transfer to new rules to the group which only had to memorize the alphabet. Dependable differences were not found between the group that was given the rule and the group that was required to derive the rule.

Haslerud and Meyers (1958) presented to college students 20 coding problems designed to give the students two types of learning experiences. One-half of the problems included rules which told the subjects how to encode cryptograms. The other half of the problems required the subjects to derive rules for themselves. The given and derived problems were alternated. On tests of learning, the subjects scored higher on the problems which included the rule than the problems which required the subjects to derive the rule. On a delayed test of transfer to new examples, no reliable difference in performance on the two types of problems was found. However, the scores were dependably increased for the problems which had no rule given, while the scores were dependably decreased for the problems which had the rule given. The authors took this finding as evidence that independently derived principles are more transferable than those given. Wittrock (1963) points out that if practice at "discovering" were generalized to the related items, the experimental design may have contaminated the results since all

subjects were given equal practice on each of the two experimental treatments.

Wittrock (1963) taught college students to decipher transpositional cryptograms by one of four treatments. The "rule and answer given" group was presented with rules as well as answers to cryptograms. They were required to copy the answers. The "rule given, answer not given" group received rules, but were required to solve the cryptograms without benefit of having the answers. The "rule not given, answer given" group was required to derive rules from answered examples, while the "rule not given, answer not given" group was required to derive the rule without benefit of the answers. The treatment which presented rules and answers produced the greatest learning, but the treatment which presented rules and required the subjects to apply the rule to unanswered examples produced the greatest retention and transfer to new examples. These results were in close agreement with Craig (1956) and Kittell (1957), and were later supported by Wittrock and Twelker (1964a).

Wittrock (1964) reports a series of experiments on the relative effects of three different types of verbal cues given to young children while they were solving concept identification problems. It was hypothesized that a linear relationship existed between the specificity of the verbal cue and the specificity of the transfer produced by the verbal cue. Children were given extensive preliminary training which taught them the correct names of several concepts. The experimental groups were then formed and the children were asked to solve problems which involved matching one of two bottom pictures to a top model picture on the basis of a concept. One treatment work group was given only the general cue to match the pictures. A second treatment group was given practice at the same problems but with the experimenter speaking the verbal label for the correct concept. The third treatment condition was like the other two except that the experimenter spoke the verbal label for the particular instance of each concept as it appeared on the screen. The children who were given the verbal label for the correct concept were dependably superior to the other treatment groups on all measures of retention and transfer. For further details

see Wittrock, Keislar, and Stern, (1964).

Although not all studies on learning by discovery indicate that verbal cueing produces the greatest learning, retention, and transfer, most of the well controlled studies indicate that verbal cues which specify rules can help a learner to transfer to other examples of those same rules. Much of the difference between the results of the many studies on learning by discovery is due to the different use of the same labels to describe the independent variables and the many different dependent variables used in these studies, (Wittrock, 1963). Some of the studies on learning by discovery are interested in developing positive attitudes toward learning rather than in teaching specific rules or ideas. It is difficult to relate the results of these studies to the other studies which emphasized the learning of content. However, it is clear that learning by discovery does not always produce the greatest liking for the subject matter, (Morgan, 1944). Learning by discovery appears to be an exciting way to learn provided that the discovery produces a fair amount of success during learning.

From the above studies, it seems safe to conclude that experimenter-presented cues, in terms of rules and answers, have an important effect on the learning and transfer of those specific things which were taught. If the stimuli provide practice and reinforcement for applying concepts, retention and transfer to new instances of those same concepts is enhanced. Of course, this generalization can be applied only to the types of subject matter taught in these studies.

Feedback. Many studies have been conducted with a wide range of materials on the effect of knowledge of results on learning. Almost none of these studies used transfer as a dependent variable. These studies date back to Judd (1905) who showed that performance improved rapidly when a learner is given knowledge of results in a direction-estimation task. Since then, the effectiveness of using knowledge of results has been shown in tasks as diverse as two-handed coordination tests (Elwell and Grindley, 1938-9), line-drawing (Trowbridge and Cason, 1932), reading (Sims, 1928; O'Brien, 1921) and verbal learning from films (Michael and Maccoby, 1953;

Maccoby, Michael, and Levine, 1961). These and many other studies not directly related to the present research have been reviewed by Ammons (1956). Wolfe, in discussing the application of learning principles to training, states that "laboratory studies are unequivocal in emphasizing the importance of giving a subject as specific and as immediate information as possible concerning the outcome of his efforts" (1951, p.1267).

The work of Pressey represents an early attempt of educational psychologists to apply immediate knowledge of results to classroom learning.² In the 1920's, it was suggested that a self-scoring multiple-choice test could serve as an instructional device (Pressey, 1926; 1927; 1932). Devices were used which automatically provided subjects with immediate knowledge of the correctness of the response to objective questions. In summarizing a series of studies done during the late 1940's, Pressey concluded that "when the self-instructional tests were used systematically in college courses as an integral part of the teaching method, gains were substantial and sufficiently generalized to improve understanding of a topic as a whole--even help on related topics." (1950, p.445)

Pressey's devices were primarily testing devices, and their limited acceptance was probably on account of this reason. Further, technology in education, in the form of audio-visual aids, motion pictures, and tape recorders had not been introduced. Almost three decades after Pressey's work had begun, Skinner (1954) suggested that the extensive laboratory research on behavior had direct bearing on the teaching process. It was pointed out that the application of research findings could be effectively brought about by a mechanical device. An experimental teaching machine was described which presented materials in a carefully organized sequence and required active response

2. A review of the research based on Pressey's concepts has been reported, among others, by Stolurow (1961, pp. 194-117).

from the learner. Skinner considered immediate reinforcement of the learner's response as a most important feature of the machine.

Typically, reinforcement in teaching machines takes the form of feedback, either confirmation of the correct response, or knowledge of the correct response. However, empirical evidence has failed to show advantages of presenting feedback in small-step programming. Holland (1960) taught college students a part of an introductory psychology course using three different treatments. The first treatment group was trained using confirmation of the correct answer following the learner's overt responses. The second group received no confirmation following their responses, while the third group was required only to read complete statements with no opportunity for an overt response. The first and second groups failed to differ dependably on a test lesson used to diagnose individual deficiencies on the materials covered earlier. Holland concluded that a low error-rate program made the answers obvious to the learners, and that feedback was not important.*

Moore and Smith (1961) conducted two experiments which hypothesized that providing immediate knowledge of correct response would increase the amount retained over a period of two weeks. The results of both experiments failed to support this hypothesis. Of interest is the fact that subjects who did not receive feedback performed better (though not dependably better) than those who received feedback. Moore and Smith suggested that presenting too much information may reduce active participation of the learners, thereby reducing learning efficiency.*

Feldhusen and Birt (1962) used college students from general psychology classes and taught the topic of teaching machines and programmed instruction. Nine different presentations of the programmed material were studied. An examination of the two groups which varied immediacy of feedback failed to reveal dependable differences. The authors concluded that the need to check answers at each frame may be unnecessarily time-consuming.* Evans, Homme, and Glaser (1962), using learning programs in symbolic logic, obtained results consistent with the above. In both of the above studies, the group which received

* Since no significant differences were found such a conclusion by these authors is highly tenuous and is not justified.

delayed feedback made slightly fewer errors on the performance tests than the group whose confirmation of responses was immediate.

Brackbill, Wagner, and Wilson (1964) studied the effect of immediate and delayed feedback using two criteria: learning and retention. The material for the learning task consisted of 18 French words and their English equivalents. On each learning trial, subjects were presented with the correct French-English pair of words on one card, and an incorrect pair on another card. If the subjects responded correctly or incorrectly, feedback, either immediate or delayed by 10 seconds, was given. Further, if subjects responded correctly, a small token reward was also given which could be exchanged for a toy at the end of the experimental session. It was found that delayed feedback was as conducive to learning efficiency as immediate feedback, but that delayed feedback was more effective for retention than immediate feedback. Subjects who had immediate feedback made more errors in relearning and took more trials to relearn than did the delayed feedback subjects. It is interesting to note that these results are inconsistent with current thought about the positive effect of immediate feedback.

Krumboltz and Weisman (1962) investigated the effect of six schedules of reinforcement in programmed learning by omitting various patterns of confirming answers from a conventional self-instructional program. The results indicated that a negative linear relationship existed between the number of errors made on the program and the percentage of reinforcement provided. A 100% reinforcement schedule caused the fewest program errors. However, the authors failed to find dependable differences on a 50-item completion test. Evidence presented by Lambert (1962) agrees with these results. He found that varying amounts of feedback were not dependably related to scores on immediate and delayed tests of learning.

In summary, these studies are not very helpful to the present experiment because they did not often use transfer as a criterion. Most have failed to find dependable differences between procedures which present immediate feedback and procedures which withhold or delay feedback when learning is the criterion. These results seem incongruous

with the studies that report feedback to be an important variable of learning. Ausubel (1963) states that studies of feedback in an automated instruction context have generally failed to consider other relevant non-feedback variables such as step size, task difficulty, and clarity of presentation. Brackbill, Wagner and Wilson (1964) suggest that the operations of a teaching machine (or more correctly, a program) make simultaneous use of several learning conditions which confound the separate contributions of each. An important variable which has been shown to influence the efficacy of feedback is the prompting procedure which is used to present information before the learner responds. These experiments, mostly on paired-associate learning, are reviewed below.

Feedback as it relates to prompts. The effect of feedback as it relates to prompting has been studied in simple learning tasks. Cook and Kendler (1956; see also Cook, 1961) compared a prompting situation with a no-prompting, confirmation procedure. On prompted trials, they showed the correct response pattern (a nonsense drawing) before the stimulus term (a letter of the alphabet). The correct response was shown before subjects were asked to respond to it. On confirmation trials, subjects were asked to respond to the stimulus letter before being prompted by the presentation of the correct response figure. It was shown that prompting was superior to confirmation. These results were later verified by Cook (1958) and Cook and Spitzer (1960).

Briggs (1961), using a device called the Subject-Matter Trainer, gave high school students three types of learning experiences: paired-associate learning, serial-learning tasks, and problem-solving tasks. Two of the four practice conditions employed by Briggs are relevant to the present discussion. The prompting mode showed the correct answer to the learner before he responded. The single-try confirmation mode gave the learner feedback after he responded, and required him to acknowledge the correct answer. The former condition corresponded to Cook and Kendler's prompting procedure while the latter condition corresponded to their confirmation procedure. The results verified Cook and Kendler's findings that prompting was superior to

confirmation.

Angell and Lumsdaine (1961a) studied the relative effectiveness of prompting trials and confirmation trials in paired-associate learning. Incompleteness of prompting was a matter of frequency of providing the correct answer before the learner responded, rather than the degree of prompting provided on any one trial. The prompting-only condition presented the stimulus letter to the learner, then the response pattern, and required the learner to draw the response term. The prompting-plus-confirmation group received three trials as described above, but on the fourth trial, subjects tried to produce the response pattern corresponding to a particular stimulus term before seeing the correct response pattern. The results showed that learning was more efficient under the prompting-plus-confirmation condition than under the prompting-alone condition. The results contradict the previous studies that suggest that maximum prompting (in terms of frequency of providing the correct answer before the learner responds) produces the greatest learning.

In a later experiment, Angell and Lumsdaine (1961b) used paired associates and somewhat different procedures and response patterns. Two experimental variables were studied: number of initial prompting trials, and degree of correction provided following errors on anticipation trials. Learners were given one, two, or three prompting trials prior to responding by anticipation. The correction procedures included confirmation (knowledge of the correctness or incorrectness of the response), KCR (giving of the correct answer), and intermediate, partial-correction procedures which gave subjects two or more alternative answers, one of which was correct. Results of the first experiment showed that a prompting trial was more effective than an anticipation trial when partial correction but not full correction was used. Further, full correction was superior to partial correction when subjects had not been prompted. Results of a second experiment failed to show the advantage of prompted trials over anticipation trials.

Swets, et. al. (1962) applied the procedures of automated instruction to the task of learning to identify multidimensional non-verbal sounds. In their first experiment, the finding that their prompting procedure was

superior to a procedure which presented KCR after each trial, was in agreement with the positive results reported above.

More recently, Wittrock and Twelker (1964a) gave different amounts of information, i.e., rules or no rules, to subjects and studied the effects of feedback. Dependable interactions revealed that the presentation of feedback, in the form of knowledge of correct response, increased scores on tests of learning, retention and transfer, to a greater extent when rules were not given than when rules were given. The results also showed that subjects who received rules or KCR rated the learning task as more enjoyable than subjects who received both rules and KCR or neither rules nor KCR.

In summary, it has been shown in paired-associate and problem-solving training that prompting is generally superior to feedback. However, it is not clear which factor is more effective in enhancing transfer.

Beyond this generalization, the research literature is not very helpful, especially if one is interested in transfer and savings as dependent variables. It seems that prompting and feedback may interact with each other and that redundancy is not necessary for learning to occur.

CHAPTER III

HYPOTHESES

From the mediation paradigm described in Chapter I above and from the research summarized in Chapter II above, four hypotheses were developed and were tested in the study. The first hypothesis predicts a primary effect of the rule variable on the test of transfer to new problems of the previously learned rules.

Hypothesis I. When transfer to deciphering new examples of previously learned rules is a criterion, a procedure which specifies relevant rules, compared with a comparable procedure which does not specify the relevant rules, increases performance.

The rules probably serve as verbalizations for mediators which enable the learner to solve a variety of problems within that particular class. This primary effect of the rule variable has been found several times before (Wittrock, 1963; Wittrock and Twelker, 1964a and 1964b). The explicit verbalization of the B terms (see Chapter I) seems to increase transfer to the other problems where these B terms are relevant. However, this hypothesis has not been studied previously with secondary school students. Whether these rules will help secondary school students to mediate across a variety of transpositional cryptograms was not known but was studied in this experiment.

The second hypothesis is presented below. Whether or not answered examples without rules produce greater transfer than rules without answered examples depends upon the type of test used to measure the results.

Hypothesis II. Giving rules and unanswered examples, compared with a procedure which does not give rules but gives answered examples, increases performance on a transfer test which involves applying previously learned rules to the deciphering of new examples of the same rules.

There is little in the research literature which is pertinent to the next hypotheses, hypotheses III and IV, which relate prompts to feedback. In a 2x2x2 design, Wittrock and Twelker (1964a) studied the effects of prompts and feedback on learning, retention, and transfer.

(This study was mentioned in Chapter II above, but needs to be mentioned again here.) Rules as prompts were either given or not given before the learner responded to problems that represented each of ten transpositional cryptograms. Feedback, which specified the rule as well as the correct answer to the problem, was either given or not given after the learner responded to the problems. A relation between prompting and feedback was hypothesized and supported. That is, when feedback is not redundant with the prompt, learning, retention, and transfer were increased by the feedback. That study investigated only the redundancy of rules. It did not investigate the effect of redundancy of answers. The present study investigated feedback which follows rules given as prompts and separately investigated feedback which follows answers given as prompts. That is, the hypothesis developed by Wittrock and Twelker (1964a) was divided into hypotheses, each of which was tested.

Hypothesis III: Feedback, which specifies the rule and the correct answers to problems that represent the rule, enhances the performance on tests of retention and transfer to new examples of the learned rules to a greater extent when rules as prompts are not given to learners than when rules as prompts are given to learners.

Hypothesis IV: Feedback, which includes the correct answers to the problems, enhances performance on tests of learning to a greater extent when answers as prompts are not given to learners than when answers as prompts are given to learners.

For the reasons given in Chapter II, the answer variable may have a greater effect upon learning than upon transfer. Therefore, when answer prompts are not given to learners, feedback which includes the correct answers should increase initial learning of a few associations.

Although no specified hypotheses about them were stated, motivation and affectivity produced by the treatment conditions were also investigated. These two variables were measured in both experiments.

Transfer to new rules, including both transpositional and substitutional rules, was also measured. Hypotheses which mention these dependent variables are not specified. Although one could derive such hypotheses from the mediation hypotheses, at this time there is not sufficient empirical data to warrant predictions about these dependent

variables.

In the original proposal for Project 1430, it was also hypothesized that on a transfer test, which involved the derivation of rules, a learning condition which gives answered examples without rules would produce greater performance than a comparable condition which gives rules and unanswered examples. After the proposal was written, a second review of the literature of learning by discovery and on verbal mediation indicate little support for the hypothesis. It was not tested in the study.

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CHAPTER IV PILOT STUDIES

The preliminary work consisted of four pilot studies. The first study used upper-division college students, while the other three studies used secondary school students. The primary purpose of these studies was to find independent variables which would be related to transfer. A second purpose was to develop materials for use in experiments.

Pilot Study I

This study investigated two variables: (a) verbal cues: rules or answered examples, and (b) variety of classes of problems: transpositional or transpositional and substitutional. One purpose of the study was to determine whether the advantage of prompting Ss with rules rather than specific answers (cf., Wittrock, 1963; Wittrock and Twelker, 1964a) would occur when S has practice with a variety of classes of problems rather than with only one class. It was shown that rules or a variety of classes facilitated transfer.³

Pilot Study II

The difficulty level (for college students) of 8 different transpositional cryptograms was determined from the data of the previous experiment. One of the medium-difficulty cryptograms was taught to 11th grade students to determine the various problems encountered in teaching cryptography to a secondary school population.

Two types of lessons were prepared. The first lesson taught S to decipher cryptograms by presenting enciphered sentences and answers. S was supposed to derive a rule from the examples, and to solve subsequent problems. The second lesson taught S a rule which could be used to decipher cryptograms.

The results showed that the lesson presented many concepts in a very short instructional sequence. The derivation of the rules by 11th grade students was difficult, and special techniques were necessary to teach this skill. The results also indicated that an affectivity rating scale used with college students was suitable for use with 11th grade students.

³This study was reported by Wittrock and Twelker (1964b).

Pilot Study III

From the findings of the second pilot study, a less complicated cryptogram was developed. The third study taught this new cryptogram in the four different types of lesson mentioned in the proposal. These lessons were:

- 1) Answer given, Rule given
- 2) Answer given, Rule not given
- 3) Answer not given, Rule given
- 4) Answer not given, Rule not given

New tests of transfer were devised and administered. Twenty-eight eleventh grade students were used as subjects.

It was shown by using the Wilcoxin Signed Ranks test for equal n that answers with examples produced more correct responses (lower error rate) than examples without answers. The rule variable failed to show dependable effects on error rate. Again, Ss had special difficulty in deriving rules on the lesson. No dependable differences were shown on the transfer test. Some of the items in the transfer-to-new examples test were too easy, while items on the transfer-to-substitutional rules test were too difficult. It was shown, to no one's surprise, that items that had a mean difficulty level of about .50 provided maximum discrimination.

Pilot Study IV

From the results of Pilot Study III, the four experimental lessons were extensively revised and new transfer problems constructed. The purpose of this fourth study was to test the revised materials before a full-scale experiment was conducted. Twenty-two tenth-grade students, six eleventh-grade students, and two twelfth grade students were used as Ss .

The group which received both answers and rules produced the most correct responses on the learning test. However, on transfer to new examples, the group which did not receive answers, but did receive rules, performed best. This agreed with the hypothesis about rules and transfer. The group which practiced working the problems when rules were given performed better than either the group which was given answers and rules or either of the groups (2 and 4) which was not given

the rule. The lesson on cryptography was accepted for use in the first experiment.

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CHAPTER V
EXPERIMENT I

The materials developed in the pilot studies were used to investigate the effects of two independent variables, rules and answers. Feedback was not manipulated in this study. Therefore data about Hypotheses I and II of Chapter III were obtained. The primary and interactional effects of rules and answers upon transfer were sampled. The transfer tests included tests of deciphering cryptograms and of derivation-of-rules. Experimental Design. The Ss were individually assigned at random to one of five treatment groups. Four experimental groups were formed on the basis of two variables: (a) answer; given or not given, and (b) rule; given or not given. In addition, one control group was used. The five groups were:

- (1) Answer given, Rule given
- (2) Answer given, Rule not given
- (3) Answer not given, Rule given
- (4) Answer not given, Rule not given
- (5) Control

Each of these groups was split on the basis of whether a problem-solving test or a derivation-of-rules test was given. Data for each test are reported separately.

Subjects. There were 150 eleventh grade students and 150 twelfth grade students, whose ages ranged from 15 years to 19 years. Their composite standard scores on the Iowa Tests of Educational Development ranged from 1 to 29. (See Tables 1 and 2).

Materials and Procedures. The different treatments were given simultaneously in the same room on two consecutive days of school. When Ss reported to a designated room, they were asked to read the instructions carefully and told that there was no time limit for completing the exercise. In addition, they were told they would be tested at the end of the lesson and that they should attempt to understand the lesson as well as possible.

TMI Grollier Min-Max II teaching machines presented all the written materials to all the Ss. The first ten frames were identical for all experi-

Table 1

Means and Standard Deviations for Age in Years, Quantitative Thinking Score, General Vocabulary Score and Composite Score of the Iowa Tests of Educational Development of Subjects Who Took the Problem-Solving Test

Treatment Group	Grade	n	Age	Quantitative Thinking	General Vocabulary	Composite
Answer given, Rule given	11	22	16.14 .47	11.36 4.22	13.09 5.61	13.64 4.88
	12	19	17.00 .47	15.84 5.86	15.05 5.49	17.00 5.23
Answer given Rule not given	11	16	16.19 .54	15.06 6.21	14.25 5.13	14.00 5.40
	12	18	16.94 .54	14.67 4.10	16.72 3.92	16.28 4.24
Answer not given, Rule given	11	17	16.18 .39	15.82 5.11	15.94 4.13	16.71 4.33
	12	15	16.93 .46	13.00 5.59	14.40 5.17	14.80 5.02
Answer not given, Rule not given	11	13	16.00 .58	17.15 7.36	17.62 6.04	18.00 6.12
	12	27	17.04 .44	14.93 5.57	13.26 4.71	14.85 4.58
No Learning Experience	11	12	16.25 .45	16.90 7.61	17.80 8.39	17.70 8.11
	12	8	17.38 .74	11.20 5.17	16.00 4.47	14.20 6.98

Table 2

Means and Standard Deviations for Age in Years, Quantitative Thinking Score, General Vocabulary Score and Composite Score of the Iowa Tests of Educational Development of Subjects Who Took the Derivation-of-Rules Test

Treatment Group	Grade	n	Age	Quantitative Thinking	General Vocabulary	Composite
Answer given, Rule given	11	11	16.18 .40	13.67 4.69	13.44 7.38	15.50 5.42
	12	8	17.38 .74	13.60 5.32	14.29 4.35	14.80 3.63
Answer given, Rule not given	11	13	16.31 .48	15.30 5.40	14.80 5.03	13.56 6.80
	12	16	17.06 .57	17.31 6.36	15.38 5.49	17.54 5.81
Answer not given, Rule given	11	19	16.32 .48	13.15 9.25	12.92 5.89	13.00 7.69
	12	15	16.93 .70	15.00 5.59	17.33 4.12	16.56 5.03
Answer not given, Rule not given	11	18	16.00 .34	15.12 5.56	13.76 5.70	13.82 5.54
	12	16	17.13 .72	17.58 6.04	14.50 3.85	16.58 4.98
No Learning Experience	11	9	16.11 .60	18.75 6.20	18.43 5.19	20.00 5.69
	12	8	17.00 .00	15.80 9.04	16.00 6.28	16.60 6.11

mental treatments and presented general information about the cryptograms. The next six frames represented the manipulation of the two variables. Answers to examples were either given or not given, and rules were either given or not given, depending on the experimental treatments.

A transpositional cryptogram is characterized by a rearrangement of the letters among themselves according to a systematic rule (see example below). Ss who were given rules or answers were required to copy the rule or specific answer to hold constant overt practice across treatments. At the end of the lesson, Ss were asked to rate the learning experience on a seven-point affectivity scale.

One transfer test required Ss to decipher cryptograms. The second transfer test required that rules be derived from answered examples. Since the working of one test could possibly contaminate the results of the other type of test, different Ss were used for each test. Six problems appeared on each test. Three of the problems represented new examples of a learned rule. The other three problems represented examples of a different class of rules (substitutional rules). Twelve different forms of each test were given randomly.

Without prior learning the control group received either the problem-solving test or the derivation-of-rules test. All Ss were asked to rate the test on a seven-point affectivity scale.

The transpositional rule taught in the lesson, an example of the rule, and an example of each of the two types of transfer tests cryptograms appear below.

Rule: In each group of letters, place the first half of the letters behind the last half. Then separate the letters into words.

Example: FAITHE SCORWA FULLOR
THE FAIR WAS COLORFUL

Transfer-to-new-examples of learned rules test item

ORDO AS MARE OFDE ODWO
DCORS ARE MADE OF WOOD

Transfer-to-new-class of rules

THEWESTCN ASTISCOOK
THE WEST COAST IS COOL

Results and Discussion

Because the n for the various treatment groups was not equal, the general linear hypothesis model (Kempthorne, 1952, pp. 234-251) was used to obtain estimates of the statistical significance of the primary and interactional effects of the variables. In addition to the two independent variables mentioned above, a third variable, grade, was used in the analysis of the four experimental treatment groups. The control group was used to provide a measure of performance without prior learning. It was not included in the analysis of variance or covariance.

The Problem-Solving Test. From Tables 3 and 4, the Rule variable produced a dependable effect on the transfer-to-new-examples test. ($F=36.53$, $p<.05$). The groups that were given rules scored higher than the groups that were not given rules. These results support previous findings (Wittrock, 1963; Wittrock and Twelker, 1964a) and also Hypothesis I, and suggest that giving rules enables Ss to transfer within that class of cryptograms better than not giving rules. This is the case whether rules are presented to college students or to public secondary school students. The rule variable was not significant in producing effects on a transfer-to-substitutional rules test.

The answer variable produced no dependable differences on either of the transfer-test scores, but did produce dependable differences on the affectivity ratings, both on the lesson and the transfer tests. The groups which were not given answers to examples rated the lesson and the test dependably higher than the groups which were given answers to examples ($F=5.97$, $p<.05$ for the lesson; $F = 4.12$, $p<.05$ for the tests). Apparently, giving rules enhances transfer to new examples, but providing opportunities to apply these rules is important in increasing affectivity toward the learning experience as well as the testing experience.

Hypothesis II predicted that the rule given, answer not given group would perform on the transfer-to-new-examples test better than the group given the answers but not the rules. By t test, the hypothesis was supported ($p<.01$). See Table 3.

On the transfer-to-new-examples test, the twelfth grade students were dependably higher than the eleventh grade students ($F = 10.26$, $p<.01$). Because of variation between mean scores on the Iowa Test of

Table 3

Treatment Group Means and Standard Deviations by Grade for the Transfer Tests Scores and for the Affectivity Ratings on the Problem-Solving Test

Treatment Group	Grade	n	Transfer New Example (3 items)	Transfer Substituti- tional Rules (3 items)	Affectivity: Program	Test
Answer given, Rule given	11	22	1.00 1.35	.68 1.23	3.41 1.89	2.45 1.82
	12	19	1.84 1.30	1.21 1.32	4.11 1.70	3.26 1.66
	11	16	.69 1.25	.88 1.02	3.69 2.36	2.75 2.08
	12	18	1.44 1.04	1.28 1.32	3.89 1.60	2.72 2.02
Answer not given, Rule given	11	17	1.53 1.46	.82 1.01	4.29 2.02	2.94 2.01
	12	15	2.53 1.06	1.27 1.16	5.00 1.56	3.87 1.96
	11	13	1.15 1.34	1.23 1.30	4.54 1.90	3.69 2.46
	12	27	1.37 1.45	1.33 1.33	4.33 1.82	3.44 2.12
No Learning Experience	11	12	.17 .39	1.67 .98		3.08 1.38
	12	8	.25 .71	1.38 1.19		3.38 1.51

Table 4

Summary of the Three-way Analysis of Variance for the Transfer Tests Scores
And for the Affectivity Ratings on the Problem-Solving Test

Source	df	Transfer to New Examples		Transfer to Substitution- al Rules		Affectivity Program		Affectivity Test	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	5.71	3.36	.82	.56	20.76	5.97*	16.66	4.12*
Rule (R)	1	11.09	6.53*	1.19	.82	.29	.08	.02	.00
Grade (G)	1	17.44	10.26**	4.79	3.31	4.38	1.23	4.67	1.16
A x R	1	1.50	.89	.10	.07	.52	.15	.72	.18
A x G	1	.31	.19	.33	.23	.35	.10	.02	.01
R x G	1	1.67	.98	.48	.33	4.34	1.25	8.87	2.19
A x R x G	1	1.08	.64	.10	.07	.38	.11	.25	.06
Error	139	1.70		1.45		3.48		4.04	

* $p < .05$

** $p < .01$

Table 5

Summary of the Three-way Analysis of Covariance for the Transfer Tests Scores
And for the Affectivity Ratings on the Problem-Solving Test

Source	df	Transfer to New Examples		Transfer to Substitution- al Rules		Affectivity: Program		Affectivity Test	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	2.80	2.20	.26	.20	14.70	4.80*	10.24	3.00
Rule (R)	1	18.71	14.69**	.26	.20	2.40	.78	1.28	.38
Grade (G)	1	18.91	14.85**	5.21	3.93*	5.04	1.64	5.63	1.65
A x R	1	1.84	1.45	.06	.05	.72	.23	.48	.14
A x G	1	1.09	.86	.11	.08	1.04	.34	3.27	.96
R x G	1	.27	.22	.07	.06	1.73	.56	4.13	1.21
A x R x G	1	4.00	3.15	.71	.54	2.49	.81	2.84	.83
Error	138	1.16		1.32		3.06		3.41	

* $p < .05$

** $p < .01$

Educational Development, an analysis of covariance was run. The Quantitative Thinking score was used as the concomitant variate. The results noted above did not change appreciably. Two exceptions are noted. Twelfth grade students performed dependably better than eleventh grade students on the transfer-to-substitutional rules test ($F=3.93$, $p<.05$). Also, the answer variable failed to produce a dependable effect on the affectivity rating on the transfer test. Table 5 presents a summary of the analysis of covariance for the various dependent variables.

The results support previous studies in this series and imply that rules affect transfer-to-other examples of these same rules provided the prompts provide practice and reinforcement for responses within a class of stimuli.

The Derivation-of-Rules Test

Tables 6, 7, and 8 present a summary of the results of the second set of transfer tests and of the affectivity ratings. From Table 7, it can be seen that there were not dependable treatment effects for the answer and rule variables. Further, the results failed to show reliable differences for the grade factor. When variations in quantitative thinking scores on the Iowa Test of Educational Development were statistically controlled by the analysis of covariance technique, reliable differences were obtained.

From Table 8, the rule variable produced a dependable effect on the transfer-to-new-examples test ($F=8.95$, $p<.05$). The groups that were given rules scored higher than the groups that were not given rules. The results failed to show dependable effects from the rule variable on the transfer-to-substitutional-rules test. However, the answer variable did produce reliable effects, in favor of the answer given groups ($F=4.05$, $p<.05$).

The rule variable also produced a dependable effect on the transfer test affectivity rating ($F=4.28$, $p<.05$). Groups that were given rules rated the test as more enjoyable than groups that were not given rules.

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Table 6

Treatment Group Means and Standard Deviations by Grade for the Transfer Tests Scores and for the Affectivity Ratings on the Derivation-of-Rules Test

Treatment Group	Grade	n	Transfer to New Examples (3 items)	Transfer to Substitutional Rules (3 Items)	Affectivity Program	Test
Answer given, Rule given	11	11	1.73 1.27	1.81 1.25	4.64 1.75	5.00 1.61
	12	8	1.25 1.16	1.63 1.51	3.63 1.41	3.38 2.00
Answer given, Rule not given	11	13	.77 1.01	1.62 1.45	4.23 1.96	3.15 1.86
	12	16	1.38 1.50	2.25 1.18	4.06 1.95	4.00 1.83
Answer not given, Rule given	11	19	1.21 1.18	.79 1.23	4.47 2.09	3.79 2.12
	12	15	1.47 1.51	1.60 1.55	4.20 2.11	4.00 1.65
Answer not given, Rule not given	11	18	.67 1.89	1.17 1.29	3.06 1.89	3.06 1.95
	12	17	1.00 1.37	1.75 1.24	4.25 1.91	3.56 1.90
No Learning Experience	11	9		3.00 .00		4.22 1.79
	12	8		1.88 1.55		3.88 1.81

Table 7

Summary of the Three-way Analysis of Variance for the Transfer Test Scores
and for the Affectivity Ratings for the Derivation-of-Rules Test

Source	df	Transfer to New Examples		Transfer to Substitutional Rules		Affectivity Program		Affectivity Test	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	1.03	.61	6.77	3.84	.56	.15	2.12	.60
Rule (R)	1	5.77	3.44	1.52	.87	3.01	.80	9.66	2.72
Grade (G)	1	.88	.52	5.68	3.23	.11	.30	.01	.00
A x R	1	.05	.03	.02	.01	3.31	.88	----	.00
A x G	1	.36	.22	1.53	.87	7.44	1.99	3.78	1.06
R x G	1	2.29	1.36	.61	.35	9.01	2.40	12.92	3.64
A x R x G	1	1.72	1.03	1.88	1.07	.66	.18	7.98	2.25
Error	108	1.68		1.76		3.75		3.55	

Table 8

Summary of the Three-way Analysis of Covariance for the Transfer Test Scores
and for the Affectivity Ratings for the Derivation-of-Rules Test

Source	df	Transfer to New Examples		Transfer to Substitutional Rules		Affectivity Program		Affectivity Test	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	1.27	.91	7.24	4.50*	.61	.16	2.36	.68
Rule (R)	1	12.59	8.95*	.09	.05	4.09	1.09	14.78	4.28*
Grade (G)	1	.01	.01	3.02	1.88	.31	.09	.40	.11
A x R	1	.04	.02	.03	.02	3.27	.87	.01	.00
A x G	1	.09	.06	1.00	.62	6.97	1.85	3.00	.87
R x G	1	1.38	.98	.27	.17	8.43	2.24	11.29	3.27
A x R x G	1	1.29	.92	1.55	.96	.74	.20	7.35	2.13
Error	107	1.41		1.61		3.76		3.45	

*p < .05

Table 10

Treatment Group Means and Standard Deviations for the Quantitative Scores of Subjects Who Took the Problem-Solving Test

Treatment Group	School "A" ¹	School "B" ²	School "C" ³
$A_{g=30} R F_g$	16.89 6.49	6.59 1.59	273.64 14.39
$A_{g=29} R_{ng} F_g$	17.89 7.61	5.97 1.08	279.40 16.40
$A_{ng=29} R_g F_g$	19.20 7.18	6.44 1.23	278.36 11.40
$A_{ng=28} R_{ng} F_g$	15.78 4.18	6.80 1.81	281.86 8.86
$A_{g=22} R_g F_{ng}$	16.50 7.37	7.00 1.26	268.29 13.62
$A_{g=28} R_{ng} F_{ng}$	17.31 6.88	6.40 1.00	282.63 15.02
$A_{ng=30} R_g F_{ng}$	20.09 4.87	6.23 1.11	273.10 13.67
$A_{ng=24} R_{ng} F_{ng}$	13.67 8.00	8.00 1.00	284.00 12.07
Control $n = 25$	15.67 6.91	9.00 ----	272.31 10.62

1. Standard Scores, Iowa Tests of Educational Development

2. Stanine Scores, Iowa Tests of Educational Development

3. Converted Scores, Sequential Tests of Educational Progress

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CHAPTER VI
EXPERIMENT II: METHOD

Experiment II investigated the effect of rules and answers, as well as feedback, on three dependent variables. Because of the unavailability of subjects, feedback was studied only in relation to the problem-solving test. As in Experiment I, all treatment groups were given either a problem-solving test or a derivation-of-rules test.

Experimental Design

The Problem-solving Test. A 2x2x2 factorial design was used to study three variables (a) answer: given or not given, (b) rule: given or not given, and (c) feedback: given or not given. The eight experimental groups based on these three variables were:

1. Answer given, Rule given, Feedback given ($A_g R_g F_g$)
2. Answer given, Rule not given, Feedback given ($A_g R_{ng} F_g$)
3. Answer not given, Rule given, Feedback given ($A_{ng} R_g F_g$)
4. Answer not given, Rule not given, Feedback given ($A_{ng} R_{ng} F_g$)
5. Answer given, Rule given, Feedback not given ($A_g R_g F_{ng}$)
6. Answer given, Rule not given, Feedback not given ($A_g R_{ng} F_{ng}$)
7. Answer not given, Rule given, Feedback not given ($A_{ng} R_g F_{ng}$)
8. Answer not given, Rule not given, Feedback not given ($A_{ng} R_{ng} F_{ng}$)

In addition, one control group was presented with the learning and transfer tests without prior learning experience to establish chance performance.

The Derivation-of-Rules Test. A 2x2 factorial design was used to study two variables (a) answer: given or not given, and (b) rule: given or not given. The four experimental groups based on the two variables were:

1. Answer given, Rule given ($A_g R_g$)
2. Answer given, Rule not given ($A_g R_{ng}$)
3. Answer not given, Rule given ($A_{ng} R_g$)
4. Answer not given, Rule not given ($A_{ng} R_{ng}$)

In addition, a control group was included in the experiment to establish chance performance on the tests. The experimental design of the study is illustrated in Table 9.

Table 9

Design of the Experiment

PROBLEM SOLVING TEST

Group	Answer (A)	Rule (R)	Feedback (F)
1	1	1	1
2	1	0	1
3	0	1	1
4	0	0	1
5	1	1	0
6	1	0	0
7	0	1	0
8	0	0	0
9	Control No Learning Experience		

DERIVING RULES TEST

Group	Answer (A)	Rule (R)	Feedback (F)
1	1	1	0
2	1	0	0
3	0	1	0
4	0	0	0
5	Control No Learning Experience		

Note: A "1" indicates the presence of prompting or feedback, while a "0" indicates its absence.

Subjects

The subjects were secondary school students from three districts in the greater Los Angeles, California area. There were 383 subjects who originally participated in the experiment. Of these, 14 failed to finish the learning lessons or take the immediate test. In the analysis of the learning lessons and immediate test, data from the remaining 369 students were used. Of these, 11 were 10th grade students, 136 were 11th grade students, and 222 were 12th grade students. Participation in the experiment was mandatory for all students. Subjects were individually assigned at random to each of the experimental conditions.

On the day that the delayed test of learning and transfer was given, 53 students were absent. The analysis of the scores on this test was based on the remaining 316 students. Since regular class attendance is the norm in public schools, "self-selection" bias resulting from absentee situation was probably minimal.

Achievement test scores for subjects were obtained from the respective schools' files. Scores on these tests from each school were not directly comparable. School "A" provided standard scores on the Iowa Tests of Educational Development. School "B" provided stanine scores for the same test, while School "C" provided converted scores for the Sequential Tests of Educational Progress. Information about quantitative and verbal achievement test scores, and age, of subjects in each experimental group is found in Tables 10-14.

Equipment

To insure that subjects took the learning lesson in a controlled, reproducible fashion, TMI Grolier Min/Max II teaching machines were used. These machines fed sheets of 8 1/2 x 11 inch paper one at a time past an aperture normally covered with a plastic mask. These masks were removed for the present experiment to allow subjects to write directly on the lesson sheets within the limits of the aperture. An important characteristic of the machine was its clutch arrangement which did not allow subjects to return to a frame once they passed it. This provision was essential for adequate control of the presentation of the feedback frames to those groups involved.

Table 11
Treatment Group Means and Standard Deviations for the Verbal Scores
of Subjects Who Took the Problem-Solving Test

Treatment Group	School "A"1	School "B"2	School "C"3
AgRgFg n = 30	15.44 4.69	6.36 1.05	294.18 9.16
AgRngFg n = 29	19.44 5.41	6.23 1.07	295.80 11.01
AngRgFg n = 29	19.60 4.45	6.67 .94	293.00 11.16
AngRngFg n = 28	19.11 3.89	6.98 .76	293.75 11.81
AgRgFng n = 22	18.14 3.48	6.67 1.37	286.29 13.72
AgRngFng n = 28	17.92 4.33	6.47 .51	296.88 13.03
AngRgFng n = 30	20.64 6.04	6.68 .72	296.56 10.03
AngRngFng n = 24	18.80 4.13	9.00 ----	296.57 8.94
Control n = 25	19.89 6.29	9.00 ----	288.08 16.08

1. Standard Scores, Iowa Tests of Educational Development
2. Stanine Scores, Iowa Tests of Educational Development
3. Converted Scores, Sequential Tests of Educational Progress

Table 12

Treatment Group Means and Standard Deviations for Age of Subjects
Who Took the Problem-solving Test

Treatment Group	Age in Years
$\begin{matrix} A & R & F \\ g & g & g \\ n = 30 \end{matrix}$	16.53 1.04
$\begin{matrix} A & R & F \\ g & ng & g \\ n = 29 \end{matrix}$	16.76 .79
$\begin{matrix} A & R & F \\ ng & g & g \\ n = 29 \end{matrix}$	16.76 .69
$\begin{matrix} A & R & F \\ ng & ng & g \\ n = 28 \end{matrix}$	16.96 .74
$\begin{matrix} A & R & F \\ g & g & ng \\ n = 22 \end{matrix}$	16.55 .67
$\begin{matrix} A & R & F \\ g & ng & ng \\ n = 28 \end{matrix}$	17.00 .61
$\begin{matrix} A & R & F \\ ng & g & ng \\ n = 30 \end{matrix}$	16.90 .71
$\begin{matrix} A & R & F \\ ng & ng & ng \\ n = 24 \end{matrix}$	16.88 .74
Control $n = 25$	16.88 .67

Table 13
Treatment Group Means and Standard Deviations for the Quantitative
Scores and Verbal Scores of Subjects Who Took the Derivation-of-Rules
Test

Treatment Group	School "A"1	School "B"2	School "C"3
<u>Quantitative Scores</u>			
AgRg <u>n</u> = 29	16.23 7.60	6.97 1.25	275.22 11.52
AgRng <u>n</u> = 24	19.67 6.25	5.74 1.02	280.25 13.31
AngRg <u>n</u> = 22	20.50 6.11	7.68 1.04	277.13 12.55
AngRng <u>n</u> = 25	20.44 4.93	6.84 1.20	277.50 16.54
Control <u>n</u> = 24	19.00 7.09	6.33 1.53	275.82 14.01
<u>Verbal Scores</u>			
AgRg <u>n</u> = 29	19.75 4.75	6.94 1.16	291.11 9.79
AgRng <u>n</u> = 24	20.44 4.39	6.38 .88	292.25 16.46
AngRg <u>n</u> = 22	21.10 4.46	7.23 1.26	291.13 10.48
AngRng <u>n</u> = 25	18.78 7.03	6.78 1.13	281.17 20.22
Control <u>n</u> = 24	20.75 5.23	7.33 2.89	293.36 8.21

1. Iowa Test of Educational Development, Standard scores.
2. Iowa Test of Educational Development, Stanine scores.
3. Sequential Test of Educational Progress, Converted scores.

Table 14

Treatment Group Means and Standard Deviations for Age of Subjects
Who Took the Derivation-of-Rules Test

Treatment Group	Age in Years
A _g R _g <u>n</u> = 29	17.03 .63
A _g R _{ng} <u>n</u> = 24	16.83 1.17
A _{ng} R _g <u>n</u> = 22	17.14 .71
A _{ng} R _{ng} <u>n</u> = 25	16.72 .68
Control <u>n</u> = 24	17.00 .72

Procedure

A few days before the experiment, the teachers of the classes involved in the experiment informed the students of the study. Students were told that the experiment would take two class sessions, the second session to be held one week later. The students were asked to bring books to class on the day of the experiment so they could study in case they finished before the class period ended. When subjects reported for Session 1, they were given a sheet of instructions which explained facts about the machine, the experiment, and the procedure they were to follow. After the roll was taken by the teacher, the experimenter established rapport with the students and explained pertinent instructions. When the experimenter was certain that all subjects understood the procedure, the subjects were allowed to begin the lesson. The different treatments were given simultaneously in the same room. Subjects worked individually and were proctored by the experimenter. All experimental sessions were conducted on regularly scheduled school days.

Each subject was given an immediate test of learning and transfer as soon as he finished the learning lesson. Subjects raised their hands to signify that they were ready for a test. Subjects were allowed to work on the tests as long as they wanted. The tests were essentially power tests since at least 90 per cent of the students completed or terminated the tests before the end of the period. No specific questions posed by individual students concerning test items were answered by the experimenter. Five different forms of the tests were randomly given to minimize the subjects' opportunities to copy each others' work or to communicate specific answers between classes. No explicit instructions were made by the experimenter about the second session.

The delayed tests of learning and transfer were given exactly one week later. Each subject received a different form of the test he had taken earlier. Time was called when over 90 per cent of the subjects had completed the test.

Learning Lessons

The subject matter of the instructional sequences was cryptography

as used by Wittrock and Twelker (1964a; 1964b). This topic was chosen because it was readily adaptable to rule and example sequences, the test problems could be objectively scored, current or prior contamination from regular instruction was not a severe problem, and the subject matter was interesting to most secondary school students.

Each experimental lesson contained twenty frames. Of these, the first eight were the same for all treatment groups, and described the essential characteristics of transpositional cryptograms. A transpositional cryptogram is characterized by a rearrangement of letters in a message according to some systematic rule. Subjects were asked to decipher a simple cryptogram and derive a rule for it.

In the next eight frames a new and more complicated rule was taught which consisted of three distinct concepts. The concept "Place the first half of the letters behind the last half" was taught first. Examples used one group of six letters to illustrate the concept. Next, the concept of applying this cipher, "In each group of letters", was presented and two groups of six letters each were introduced as examples. Finally, "Then separate the letters into words" was presented. Subjects were required first to separate the letters of two groups and then separate the letters of three groups into words.

In six of the eight frames, the two prompting variables were manipulated. Answers were either given or not given to examples, and rules were either given or not given, depending on the experimental treatment. Two of the eight frames manipulated only the answer variable and gave subjects additional training on a particular concept which proved to be difficult in preliminary pilot studies.

Specifically, frames in the answer-not-given lessons presented enciphered messages which, when correctly deciphered by subjects, illustrated one or more of the concepts mentioned above, e.g.,

Here is another example of the same type. Only this time there are two words. Decipher each word just as you did before.

ISHFIN

ONDSEC

Frames in the answer-given lessons presented the enciphered messages and the answers which subjects were instructed to copy, e.g.,

Here is another example of the same type. Only this time there are two words. Copy the deciphered words in the box.

ISHFIN
FINISH

ONDSEC
SECOND

The rule-not-given lessons presented only an illustrative example from which subjects were required to derive the rule in writing, e.g.,

Write the rule that decipheres this sentence. Write the rule so that it applies to more than one group of letters.

The rule-given lessons presented a concept which was of value in deciphering the cryptogram. Subjects were required to copy the rule in the first frame and fill in missing words in later frames. For example,

The rule you can use to decipher these words appears below. Notice a step has been added that tells you how to decipher more than one group of letters. Fill in the blanks.
IN EACH GROUP OF LETTERS, PLACE THE FIRST HALF OF THE LETTERS BEHIND THE _____.

For the lessons which presented feedback, information as to knowledge of the correct response was presented after each frame. Specifically, the answer to the enciphered message and the rule which was pertinent to the particular example was presented. For the two frames which presented only an example, the answer to the cryptogram was given. A sample learning lesson appears in Appendix C.
Immediate and Delayed Tests of Learning and Transfer

The Problem-solving Test. The immediate and delayed tests required subjects to decipher cryptograms. Each enciphered message was a complete and sensible sentence using common English words. As classified by Thorndike and Lorge (1944), each word could be found in various literary sources at least 50 times per million words. The majority of the words were classified as being found over 100 times per million words.

Twelve problems appeared on the test. The first three problems were taken directly from the learning lesson and constituted a measure of learning in an unprompted situation. The next three problems could be worked in the same manner as the problems above, but differed in appearance from the examples presented in the lesson. Lesson

examples contained one or more groups of six letters each, while the transfer-to-new-examples problems presented different letter groupings (i.e., nine groups of two letters each). The next three problems presented encoded messages that used substitutional rules. The transfer-to-substitutional-rules problems required subjects to substitute some of the letters in the encoded sentence for other letters in the alphabet according to some systematic rule.

There were five forms of the test, each containing different problems for all but the learning test. For the learning test, the same problems were presented for all five forms.

The Derivation-of-rules Test. These tests required Ss to derive rules from answered examples. Each example represented the same cryptogram as that used in the tests in Experiment I.

Twelve types of problems appeared on the test. Three problems represented the rule as taught in the lesson; examples were taken directly from the lesson. This constituted a measure of learning in an unprompted situation. Three other problems represented the same rule as taught, but the examples differed in appearance from the examples presented in the lesson. Lesson examples contained one or more groups of six letters each, while the transfer-to-new-examples lessons presented different letter groupings (i.e., nine groups of two letters each). Three other problems presented examples that involved new transpositional cryptograms and required subjects to derive rules which had never been explicitly taught. Three other problems required subjects to derive rules from examples that represented a different class of cryptograms as that taught. These cryptograms were substitutional ciphers and involved a substitution of some of the letters in the encoded sentence for other letters in the alphabet according to some systematic rule.

Five forms of the test were given, each containing different examples for all but the learning test. For the learning test, the same problems were presented for all five forms. The four types of problems were randomly arranged on each of the five forms. The cryptograms used in the experiment appear in Appendix D.

Affectivity and Motivational Measures

At the end of the lesson, subjects were asked to rate the learning experience on a seven-point affectivity scale and to rate their willingness to learn other subject matter in the same manner. For the affectivity scale, a rating of 1 indicated that the test was frustrating, while a rating of 7 indicated that the test was enjoyable. For the motivational scale, a rating of 1 indicated that the subject was unwilling to learn other material, while a rating of 7 indicated that the subject was willing.

At the end of the immediate and delayed tests of learning and transfer, all subjects were asked to rate the tests on seven-point affectivity scales. Again, a rating of 1 indicated that the test was frustrating and a rating of 7 indicated that the test was enjoyable. In addition, on the delayed test, subjects were asked to answer the following question to determine the effect of the experimental variables on motivation to practice. "Did you practice what you learned about cryptograms at any time after the experiment last week?" A "yes" or "no" answer was requested.

Time Measures

Each classroom used in the experiment was equipped with an electric clock visible to all subjects. Subjects were asked to record five times during the course of the experiment. The first three time measures provided estimates of the time required to complete the portion of the learning lesson which manipulated the experimental variables (Frames 9-16) and the time required to take the immediate tests of learning and transfer. The latter two measures provided an estimate of the time required to take the delayed tests of learning and transfer. The dependent variables are summarized in Table 15.

Scoring Criteria

From previous studies (Wittrock, 1963; Wittrock and Twelker, 1964a; 1964b), a system of scoring was developed which proved satisfactory. Either full credit or no credit was given for learners' responses.

Criteria for Scoring Tests Which Involved Problem-Solving. Each deciphered sentence was considered correct if it met the following criteria:

1. Each deciphered sentence must contain the correct number of words.
2. Each word must appear in the correct order.
3. At least 16 of the 18 letters must be in the correct order.
4. At least 16 of the 18 letters must be in the correct letters.

These rather strict criteria provided some lenience for subjects to make spelling errors.

Criteria for Scoring Tests Which Involved Deriving Rules. Each rule was considered correct if it met the following criteria:

1. The rule could actually be used to rearrange properly the letters of an example.
2. Where applicable, the rule made some statement to the effect that the rearranged letters should be separated into words to make sense out of the message.
3. For the substitutional rules, the rule actually mentioned the particular letters that must be submitted.

Table 15

Summary of the Dependent Variables

Variable	Learning Lesson	Immediate Test	Lelayed Test
Learning		*	*
Transfer to New Examples		*	*
Transfer to New Transpositional Rules		*	*
Transfer to Substitutional Rules		*	*
Affectivity Rating	*	*	*
Motivational Rating	*		
Motivation to Practice			*
Time	*	*	*
Lesson Error Rate	*		

Note: An asterisk indicates that this measure was included in the experiment.

CHAPTER VII

RESULTS AND DISCUSSION

Methods of Analysis

Each problem on the immediate test and delayed test was scored as correct or incorrect independently by two individuals. The scores were recorded on master data sheets and double checked for accuracy. Only after this was done were the program error rates and information such as treatment number recorded. In this manner, no knowledge of the experimental treatment was available to bias or influence the scorers. (The same procedure was followed for Experiment I). Data were key punched on IBM cards and verified for accuracy.

The data were analyzed with standard parametric procedures such as analysis of variance and individual comparison tests. Packaged computer programs developed by the UCLA School of Medicine (Dixon, 1964) were used with an IBM 7094 computer to obtain the desired computations.

Administrative problems made it impossible to assure that each treatment group had an equal number of subjects. The situation was further complicated by the fact that not all subjects who took the learning program and immediate test were present for the delayed test. For this reason, it was decided to use the general linear hypothesis model (Kempthorne, 1952, pp. 234-251) to avoid arbitrarily eliminating subjects to equalize cell ns and to gain an accurate estimate of the main and interactional effects of the treatment variables.

To gain accurate estimates of simple effects and differences between individual groups in cases of dependable triple interactions, the Newman-Keuls procedure was used (cf., Winer, 1962, pp. 210-211; 238-239; 80-85). In adapting the Newman-Keuls procedure to unequal sample sizes the harmonic mean was used in place of n, as recommended by Winer (1962, pp. 101-102). The .05-level test was made on all variables.

Four analyses of the data were performed. First, using Dunnett's procedure, the control group was compared with all experimental groups

to find if the performance of the experimental groups represented chance. Second, analyses of variance were performed on the experimental groups to assess the main and interactional effects of the independent variables. Third, analyses of covariance were performed to control statistically the different levels of learning for each experimental group. Finally, supplementary analyses of variance, with achievement level as a variable, were performed to assess the effects of the independent variables in interaction with learners of different abilities.

PART I: RESULTS OF THE PROBLEM-SOLVING TEST

Comparison of All Experimental Treatment Groups with the Control Group

To assess whether the experimental treatment groups differed reliably on the performance measures from the control group, which did not receive training, Dunnett's procedure was used (cf, Winer, 1962, pp. 89-92).

Dunnett's procedure is appropriate regardless of the over-all F ratio between groups. The harmonic mean was used in place of n to make allowance for unequal sample sizes. The .05 level test (two-tailed) was made on all comparisons. Tables 16 and 17 summarize the findings for the immediate and delayed tests of learning and transfer, respectively.

On the immediate test of learning, all experimental groups scored reliably higher than the control group ($p < .05$). On the delayed test of learning, five of the eight experimental groups scored reliably higher than the control group ($p < .05$). Clearly, the training procedures produced gains in learning and retention that cannot be attributed easily to chance.

On the immediate and delayed test of transfer to new examples, every experimental group except the $A_{g_{ng}F_{ng}}$ and the $A_{ngR_{ng}F_{ng}}$ groups scored reliably higher than the control group ($p < .05$). This suggests that the training procedures which gave rules, either in the form of prompts or feedback, enhanced transfer to new examples of learned rules better than procedures which withheld rules.

None of the F ratios for the immediate and delayed tests of transfer to new transpositional rules and transfer to substitutional rules was reliable. However, use of Dunnett's procedure revealed that

Table 16

Summary of the Comparison of All Experimental Treatment Group Means with the Control Group Mean for the Immediate Test of Learning and Transfer

Group	Learning			Transfer to New Examples			Transfer to New Transpositional Rules			Transfer to New Substitutional Rules		
	Mean	D	t	Mean	D	t	Mean	D	t	Mean	D	t
1	2.90	.94	6.71*	2.20	1.52	4.79*	1.93	.25	.89	.87	-.65	-1.97
2	2.79	.83	5.93*	1.76	1.08	3.41*	1.76	.08	.29	1.17	-.35	-1.06
3	2.97	1.01	7.16*	2.31	1.63	5.14*	2.55	.87	3.11*	.90	-.62	-1.89
4	2.82	.86	6.14*	1.75	1.07	3.38*	2.04	.36	1.29	.93	-.59	-1.79
5	2.95	.99	7.07*	2.23	1.55	4.89*	2.14	.46	1.64	1.18	.34	-1.03
6	2.82	.86	6.14*	1.39	.71	2.23	1.86	.18	.60	.71	-1.15	-3.48*
7	2.63	.67	4.79*	2.20	.52	4.79*	2.03	.35	1.25	.90	-.62	-1.88
8	2.42	.46	3.26*	1.38	.70	2.21	1.96	.28	1.00	1.25	-.27	-.82
9	1.96			.68			1.68			1.52		
	F=10.01, p<.001			F=5.68, p<.001			F=1.64, p>.05			F=1.11, p>.05		

- Note 1: The symbol $\bar{D}$ refers to the difference between each experimental group mean and the control group mean.
- Note 2: The F ratio shown for each test represents a one-way analysis of variance which includes the eight experimental groups and one control group (df, 8, 236).
- Note 3: An asterisk indicates that the control group mean differed reliably from the particular experimental group mean, $p < .05$, two-tailed, as determined by Dunnett's procedure.

Table 17

Summary of the Comparison of All Experimental Treatment Group Means with the Control Group
Mean for the Delayed Test of Learning and Transfer

Group	Learning		Transfer to New Examples		Transfer to New Transpositional Rules		Transfer to New Substitutional Rules	
	Mean	D	t	Mean	D	t	Mean	D
1	3.00	.65	4.51*	2.27	1.40	4.24*	2.38	.29
2	2.67	.32	2.22	1.86	.99	3.00*	2.52	.43
3	2.96	.61	4.24*	2.35	1.52	4.61*	2.57	.48
4	2.85	.50	3.47*	1.96	1.09	3.30*	2.27	.18
5	2.70	.35	2.43	1.80	.93	2.87*	2.30	.21
6	2.82	.53	3.68*	1.52	.65	1.97	2.48	.39
7	2.84	.49	3.40*	2.40	1.53	4.64*	2.28	.10
8	2.55	.20	1.39	1.64	.77	2.38	2.32	.23
9	2.35			.87			2.09	

F=4.36, $p < .001$ F=4.35, $p < .001$ F=.60, $p > .05$ F=.87, $p > .05$

Note1: The symbol D refers to the difference between each experimental group mean and the control group mean.

Note2: The F ratio shown for each test represents a one-way analysis of variance which includes the eight experimental groups and one control group (df, 8, 202).

Note3: An asterisk indicates that the control group mean differed reliably from the particular experimental group mean, $p < .05$, two-tailed, as determined by Dunnett's procedure.

on each of the immediate tests one experimental group was reliably higher than the control group. On the transfer-to-new-transpositional rules test, the $A_{ng} R_{g} F_{g}$ group was higher than the control group. This finding suggests that transfer to new rules of the same class was enhanced when training allowed learners to practice working examples for themselves and presented feedback.

On the immediate test of transfer to substitutional rules, every experimental group performed poorer than the control group. One experimental group, the $A_{g} R_{ng} F_{ng}$ group, was reliably lower than the control group ($p < .05$). This finding suggests that training which involved transpositional concepts was not appropriate for teaching learners to solve cryptograms which represented substitutional concepts.

In light of the above analysis, the training given in this experiment transferred largely to problems that were representative of the learned concepts. The experimental lessons produced learning, retention, and transfer to new examples above that shown by chance performance. These findings indicate that further analysis of the data is appropriate.

Three-way Analysis of Variance

To assess the main and interactional effects of the three independent variables, a $2 \times 2 \times 2$, factorial experiment was used (cf., Edwards, 1960, pp. 175-100). In this type of design, a main effect of a treatment is simply a weighted average of all its simple effects. When no interaction is assumed, the simple effects are presumably the same except for chance at all levels of that factor.

Immediate Test of Learning and Transfer. Examination of Tables 18 and 19 shows that the rule variable produced a dependable effect on the learning test scores ($F = 5.37$, $p = .05$). The groups that were initially given rules relevant to solving the transpositional cryptograms in the lesson scored higher than the groups that were required to derive the rules for themselves. The rules variable also produced a dependable effect on the test of transfer to new examples ($F = 17.45$, $p < .001$). The groups that were initially given rules scored higher than the groups that were not given rules. This later result again supports previous findings (Wittrock, 1963; Wittrock and Twelker,

Table 18

**Treatment Group Means and Standard Deviations for Scores on the
Immediate Test of Learning and Transfer**

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
$A_{gR} F_{g}$ $n = 30$	2.90 .31	2.20 1.10	1.93 1.05	.87 1.22
$A_{gR} F_{ng}$ $n = 29$	2.79 .41	1.76 1.27	1.76 1.21	1.17 1.36
$A_{ngR} F_{g}$ $n = 28$	2.97 .19	2.31 1.00	2.55 .74	.90 1.21
$A_{ngR} F_{ng}$ $n = 28$	2.82 .48	1.75 1.29	2.04 1.07	.93 1.15
$A_{gR} F_{ng}$ $n = 22$	2.95 .21	2.23 1.07	2.14 .99	1.18 1.18
$A_{gR} F_{ng}$ $n = 28$	2.82 .55	1.39 1.23	1.86 1.15	.71 1.08
$A_{ngR} F_{ng}$ $n = 30$	2.63 .67	2.20 1.06	2.03 .93	.90 1.09
$A_{ngR} F_{ng}$ $n = 24$	2.42 .72	1.38 1.35	1.96 1.08	1.25 1.29
Control (No Learning Experience) $n = 25$	1.96 .79	.68 1.07	1.68 1.11	1.52 1.36

Table 19

Summary of the Three-way Analysis of Variance for Scores on the Immediate Test of Learning and Transfer

Source	df	Learning		Transfer to New Examples		Transfer to New Transpositional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	1.36	5.95*	.11	.01	2.71	2.53	.01	.00
Rule (R)	1	1.23	5.37*	24.07	17.45***	3.71	3.46	.16	.11
Feedback (F)	1	1.45	6.37*	2.31	1.67	.29	.27	.11	.08
A x R	1	.05	.22	.04	.03	.07	.06	1.00	.70
A x F	1	2.28	10.01**	.07	.05	2.74	2.55	.74	.51
R x F	1	.03	.15	1.47	1.07	.38	.36	.70	.49
A x R x F	1	.01	.03	.07	.04	1.01	.94	4.04	2.80
Error	212	.23		1.38		1.07		1.44	

* $p < .05$ ** $p < .01$ *** $p < .001$

1964a) and also Hypothesis I. Hypothesis II predicted that a treatment which specified rules but not answers, would produce greater performance on a test of deciphering new examples of previously learned rules than would a treatment which specified answers but no rules. From Table 18 Hypothesis II was supported for the groups not given feedback the only time it was tested. A Newman-Keuls procedure indicated that the $A_{ng} R_g$ group was dependably better than the $A_g R_{ng}$ group ($p < .05$). In the feedback given groups no dependable effect was given. All groups seem to do relatively well when they are given the rules through feedback. This finding does not deter from Hypothesis II because the feedback specified both rules and answers. Therefore the hypothesis was not tested when feedback was supplied.

As mentioned below, the delayed test of transfer to new examples produced, by Newman-Keuls procedure, an analogous result ($p < .05$) to that described above.

The results failed to support the third hypothesis, which stated that feedback enhances learning, retention, and transfer to a greater extent when rules as prompts are not given to learners than when rules as prompts are given.

Hypothesis IV stated that feedback enhances performance on a test of learning to a greater extent when answers as prompts are not given to learners than when answers as prompts are given. This hypothesis was supported by a dependable answer x feedback interaction ($F = 10.01, p < .01$). The dependable main effects for the answer and feedback variables must be interpreted in light of this interaction. As shown by Figure 1, feedback, which included the correct answer, enhanced learning to a greater extent when answer prompts were not given than when answer prompts were given. This finding suggests that for maximum learning, rules and answers were required. If answer prompts were not given, feedback produces the same effect when it reiterates the concept and the answer to the problem. Clearly, the worst situation in terms of learning was to give no answers in the form of prompts and no feedback. Apparently, for optimal learning, giving the rule alone is not sufficient. Further, learning does not seem to be retarded by the presentation of both

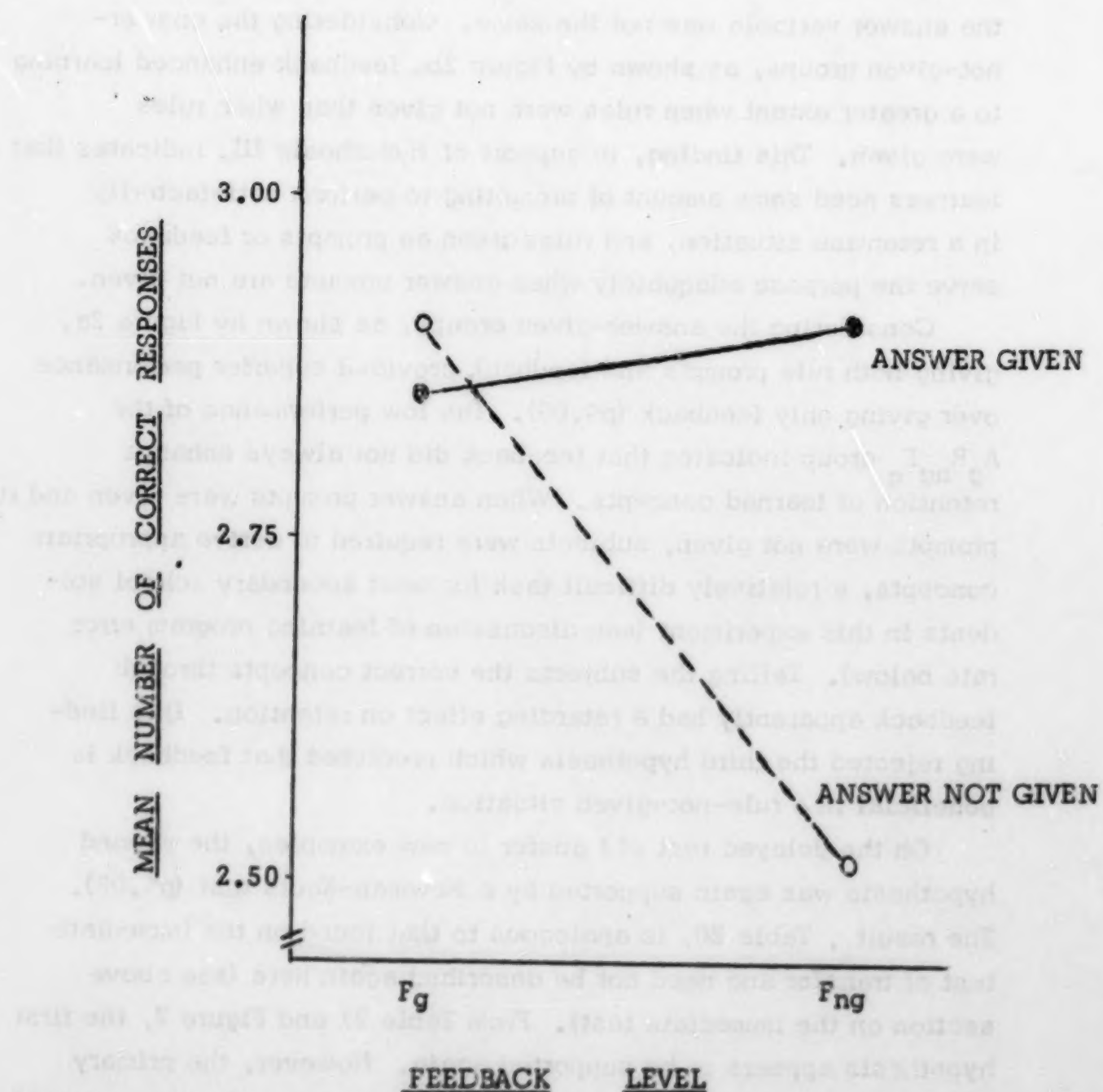


Figure 1. A x F Interaction. Profiles of Means for the Immediate Test of Learning Showing the Effect of Answers at Each Level of the Feedback Variable

rule and answer prompts and redundant feedback.

Delayed Test of Learning and Transfer. On the delayed test of learning, a reliable $A \times R \times F$ interaction was obtained ($F = 6.46$, $p < .05$), as shown in Tables 20 and 21. Examination of Figure 2 shows that the rule $\times$ feedback interaction for the two levels of the answer variable was not the same. Considering the answer-not-given groups, as shown by Figure 2b, feedback enhanced learning to a greater extent when rules were not given than when rules were given. This finding, in support of Hypothesis III, indicates that learners need some amount of prompting to perform satisfactorily in a retention situation, and rules given as prompts or feedback serve the purpose adequately when answer prompts are not given.

Considering the answer-given groups, as shown by Figure 2a, giving both rule prompts and feedback provided superior performance over giving only feedback ($p < .05$). The low performance of the $A_{gng} R_{gng} F_{gng}$ group indicates that feedback did not always enhance retention of learned concepts. When answer prompts were given and rules prompts were not given, subjects were required to derive appropriate concepts, a relatively difficult task for most secondary school students in this experiment (see discussion of learning program error rate below). Telling the subjects the correct concepts through feedback apparently had a retarding effect on retention. This finding rejected the third hypothesis which predicted that feedback is beneficial in a rule-not-given situation.

On the delayed test of transfer to new examples, the second hypothesis was again supported by a Newman-Keuls test ($p < .05$). The result, Table 20, is analogous to that found on the immediate test of transfer and need not be described again here (see above section on the immediate test). From Table 21 and Figure 2, the first hypothesis appears to be supported again. However, the primary effect of the rule must be considered with respect to the interactional effects obtained.

The interpretation of the reliable main effects of the answer and rule variables, and the rule interaction depends on the interpretation of the reliable triple interaction. When feedback was given, as shown in

Table 20

Treatment Group Means and Standard Deviations for Scores on the
Delayed Test of Learning and Transfer

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
$A_{gR}F_{g}$ $n = 26$	3.00 .00	2.27 1.00	2.38 .85	1.62 1.36
$A_{gR}F_{ng}$ $n = 21$	2.67 .48	1.86 1.15	2.52 .93	1.67 1.20
$A_{ngR}F_{g}$ $n = 23$	2.96 .21	2.39 .94	2.57 .90	1.30 1.22
$A_{ngR}F_{ng}$ $n = 26$	2.85 .37	1.96 1.25	2.27 1.04	1.42 1.21
$A_{gR}F_{ng}$ $n = 20$	2.70 .73	1.80 1.24	2.30 .80	1.65 1.39
$A_{gR}F_{ng}$ $n = 25$	2.88 .33	1.52 1.36	2.48 .71	1.20 1.26
$A_{ngR}F_{ng}$ $n = 25$	2.84 .37	2.40 .91	2.28 1.02	1.56 1.19
$A_{ngR}F_{ng}$ $n = 22$	2.55 .74	1.64 1.18	2.32 .89	1.55 1.30
Control (No Learning Experience) $n = 23$	2.35 .71	.87 1.14	2.09 1.08	2.04 1.26

Table 21

Summary of the Three-way Analysis of Variance for Scores on the Delayed Test of Learning and Transfer

Source	df	Learning		Transfer to New Examples		Transfer to New Transitional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	.01	.03	8.96	6.93**	.23	.28	.13	.08
Rule (R)	1	.56	2.72	11.60	8.97**	.03	.03	.88	.55
Feedback (F)	1	.30	1.49	.01	.01	.40	.50	.50	.31
A x R	1	.26	1.31	5.70	4.41*	.48	.60	.01	.00
A x F	1	.06	.28	3.46	2.67	.05	.06	2.28	1.42
R x F	1	.09	.45	3.81	2.95	.42	.51	2.78	1.74
A x R x F	1	1.32	6.46*	5.47	4.23*	.29	.35	.07	.04
Error	180	.19		1.29		.81		1.60	

* $p < .05$ ** $p < .01$

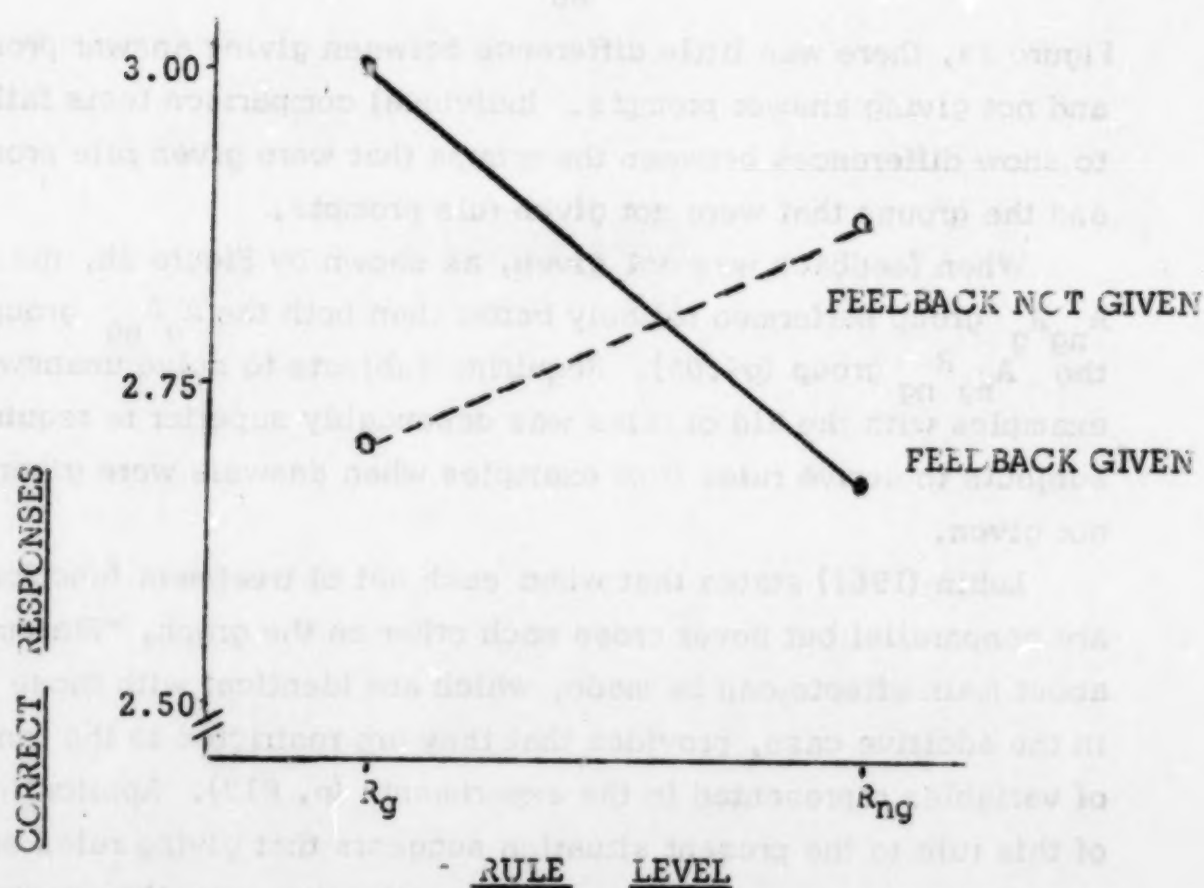


Figure 2a. ANSWER-GIVEN GRC UPS

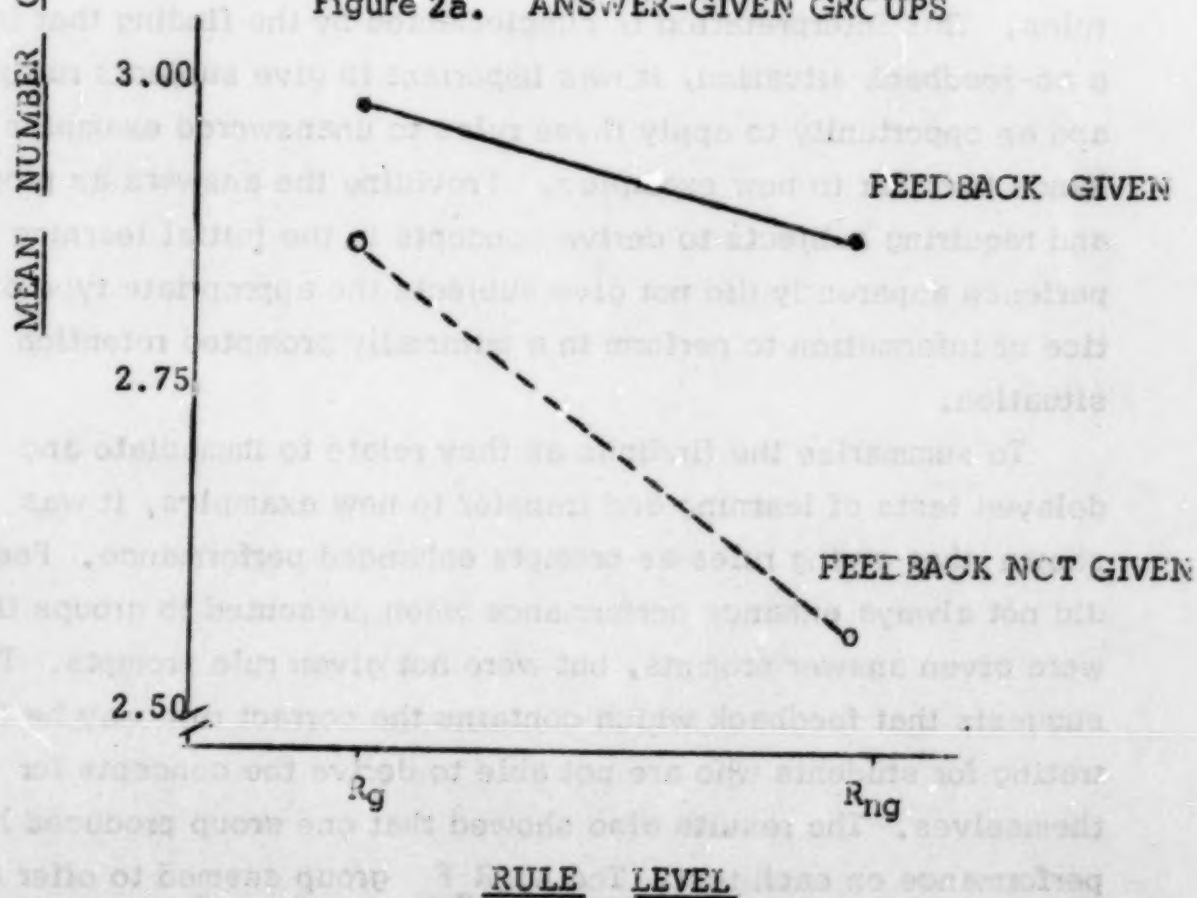


Figure 2b. ANSWER-NOT-GIVEN GRC UPS

Figure 2. A x R x F Interaction. Profiles of Means for the Delayed Test of Learning Showing the Effect of Rules and Feedback at Each Level of the Answer Variable

Figure 3a, there was little difference between giving answer prompts and not giving answer prompts. Individual comparison tests failed to show differences between the groups that were given rule prompts and the groups that were not given rule prompts.

When feedback was not given, as shown by Figure 3b, the $A_{ng} R_g$ group performed reliably better than both the $A_g R_{ng}$ group and the $A_{ng} R_{ng}$ group ($p < .05$). Requiring subjects to solve unanswered examples with the aid of rules was dependably superior to requiring subjects to derive rules from examples when answers were given or not given.

Lubin (1961) states that when each set of treatment functions are nonparallel but never cross each other on the graph, "Statements about main effects can be made, which are identical with those made in the additive case, provided that they are restricted to the range of variables represented in the experiment" (p. 812). Application of this rule to the present situation suggests that giving rules enhanced transfer to new examples in a retention situation more than not giving rules. This interpretation is supplemented by the finding that in a no-feedback situation, it was important to give subjects rules and an opportunity to apply these rules to unanswered examples to enhance transfer to new examples. Providing the answers as prompts and requiring subjects to derive concepts in the initial learning experience apparently did not give subjects the appropriate type of practice or information to perform in a minimally prompted retention situation.

To summarize the findings as they relate to immediate and delayed tests of learning and transfer to new examples, it was shown that giving rules as prompts enhanced performance. Feedback did not always enhance performance when presented to groups that were given answer prompts, but were not given rule prompts. This suggests that feedback which contains the correct rule may be frustrating for students who are not able to derive the concepts for themselves. The results also showed that one group produced high performance on each test. The $A_{ng} R_g F_g$ group seemed to offer the best relative conditions for enhancing learning, retention, and transfer.

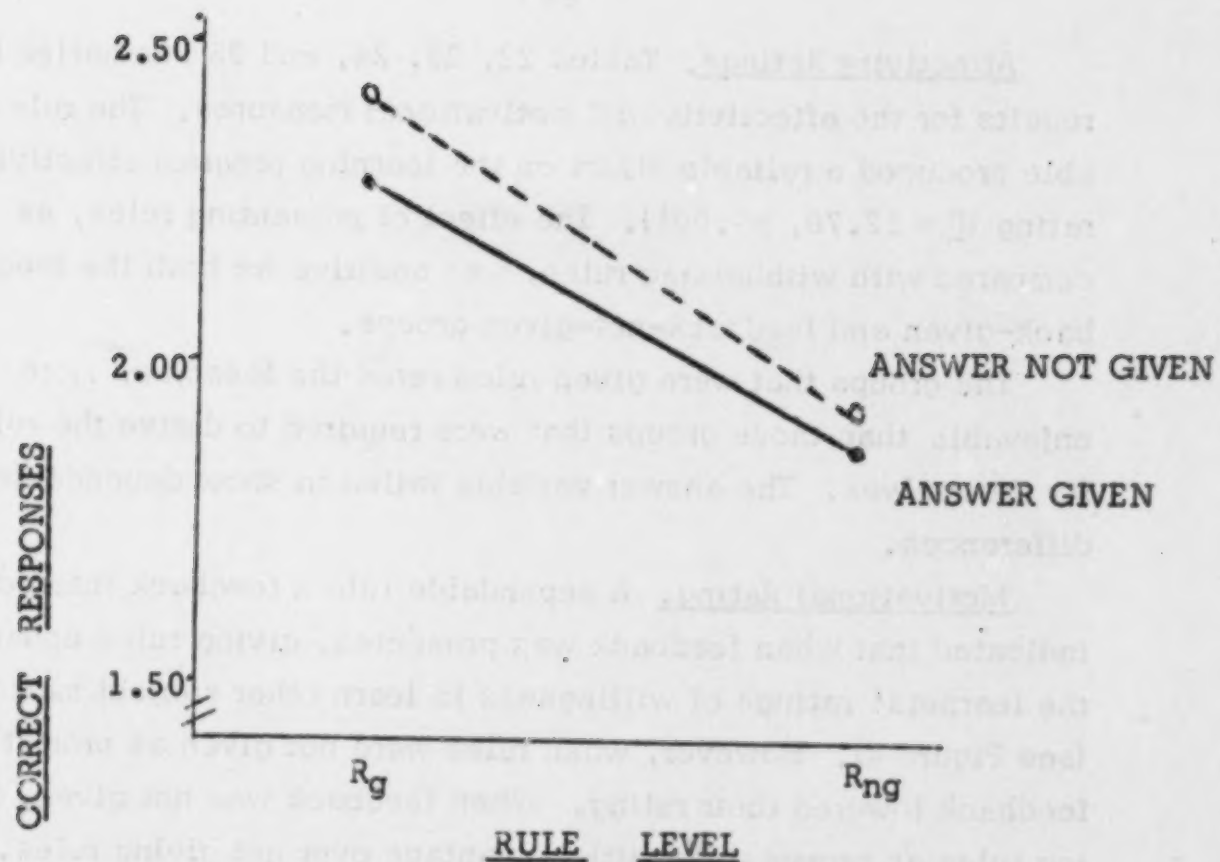


Figure 3a. FEEDBACK-GIVEN GROUPS

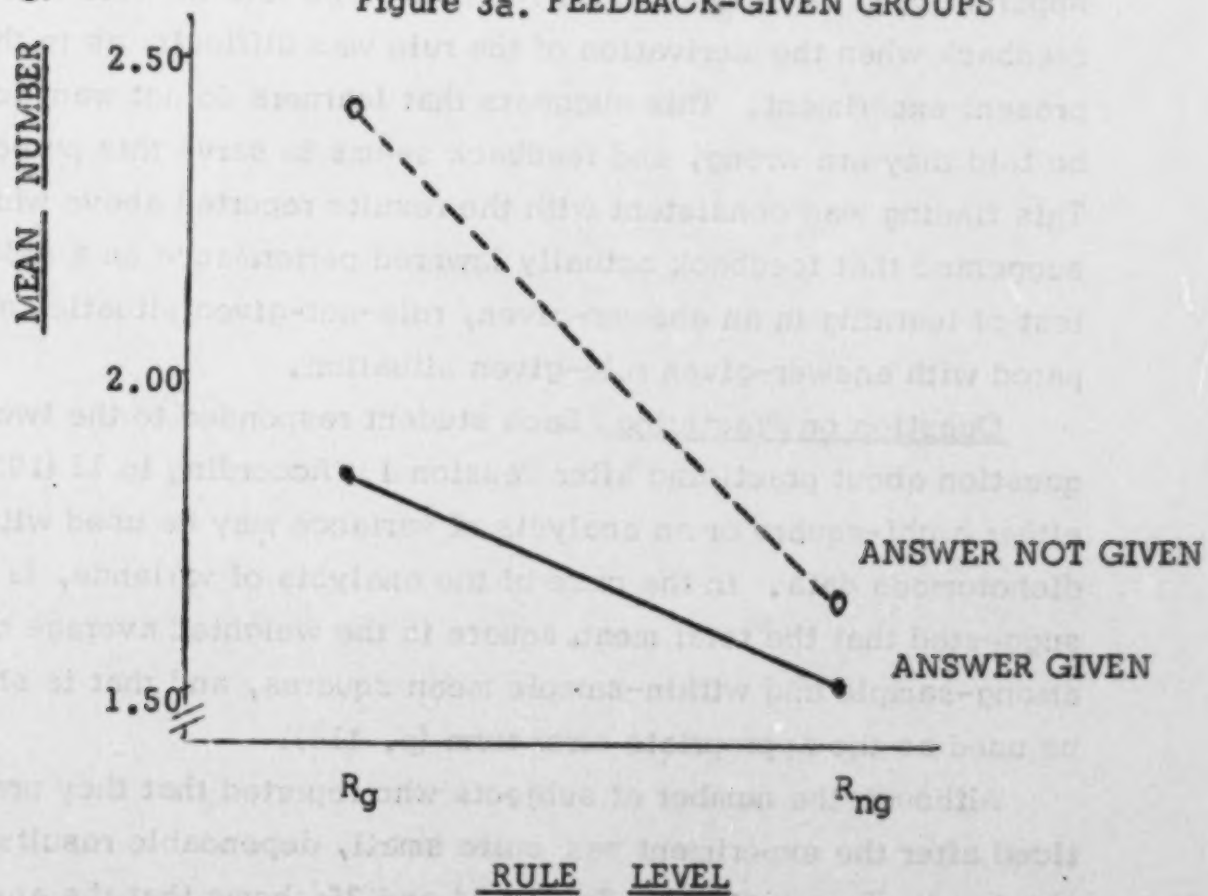


Figure 3b. FEEDBACK-NOT-GIVEN GROUPS

Figure 3. $A \times R \times F$ Interaction. Profiles of Means for the Delayed Test of Transfer to New Examples Showing the Effect of Rules and Answers at Each Level of the Feedback Variable

Affectivity Ratings. Tables 22, 23, 24, and 25 summarize the results for the affectivity and motivational measures. The rule variable produced a reliable effect on the learning program affectivity rating ($F = 12.70, p < .001$). The effect of presenting rules, as compared with withholding rules, was additive for both the feedback-given and feedback-not-given groups.

The groups that were given rules rated the lesson as more enjoyable than those groups that were required to derive the rule for themselves. The answer variable failed to show dependable differences.

Motivational Rating. A dependable rule x feedback interaction indicated that when feedback was presented, giving rules enhanced the learners' ratings of willingness to learn other subject matter (see Figure 4). However, when rules were not given as prompts, feedback lowered their rating. When feedback was not given, giving rules as prompts had little advantage over not giving rules. Apparently, it is frustrating for learners to be told the rule through feedback when the derivation of the rule was difficult, as in the present experiment. This suggests that learners do not want to be told they are wrong, and feedback seems to serve this purpose. This finding was consistent with the results reported above which suggested that feedback actually lowered performance on a delayed test of learning in an answer-given, rule-not-given situation as compared with answer-given rule-given situation.

Question on Practicing. Each student responded to the two-choice question about practicing after Session 1. According to LI (1957), either a chi-square or an analysis of variance may be used with dichotomous data. In the case of the analysis of variance, LI has suggested that the total mean square is the weighted average of the among-sample and within-sample mean squares, and that it should be used as the appropriate error term (p. 418).

Although the number of subjects who reported that they practiced after the experiment was quite small, dependable results were obtained. Examination of Tables 24 and 25 shows that the answer x rule interaction was reliable ($F = 6.29, p < .05$). Figure 5 shows that the $A_{g\ g}$ and the $A_{ng\ ng}$ groups practiced less than the $A_{ng\ g}$

Table 22

Treatment Group Means and Standard Deviations for the Affectivity
and Motivational Ratings for the Learning Lesson

Treatment Group	Affectivity Rating	Motivational Rating
$A_{g g g} R_{g g g} F_{g g g}$ $n = 30$	5.65 1.78	5.87 1.43
$A_{g n g} R_{n g n} F_{g n g}$ $n = 29$	4.71 1.69	4.41 1.99
$A_{n g n} R_{g n g} F_{g n g}$ $n = 29$	5.69 1.42	5.90 1.44
$A_{n g n} R_{n g n} F_{g n g}$ $n = 28$	5.50 1.20	4.78 2.02
$A_{g g n} R_{g g n} F_{n g n}$ $n = 22$	5.36 1.53	5.42 1.90
$A_{g n g} R_{n g n} F_{n g n}$ $n = 28$	4.18 1.91	5.13 1.81
$A_{n g n} R_{g n g} F_{n g n}$ $n = 30$	5.59 1.63	5.26 1.88
$A_{n g n} R_{n g n} F_{n g n}$ $n = 24$	4.77 1.67	5.04 1.63

Table 23

Summary of the Three-way Analysis of Variance for the Affectivity and Motivational Ratings for the Learning Lesson

Source	Affectivity Rating			Motivational Rating		
	df	MS	F	df	MS	F
Answer (A)	1	9.16	3.50	1	.08	.02
Rule (R)	1	33.23	12.70***	1	32.23	10.25**
Feedback (F)	1	9.30	3.55	1	.04	.01
A x R	1	4.23	1.62	1	.49	.18
A x F	1	.00	.00	1	1.39	.44
R x F	1	2.60	.99	1	14.46	4.60*
A x R x F	1	.48	.18	1	.22	.07
Error	212	2.62		212	3.14	

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 24

Treatment Group Means and Standard Deviations for the Affectivity Rating on the Immediate Test of Learning and Transfer, and the Affectivity Rating and the Practice Question on the Delayed Test of Learning and Transfer

Treatment Group	Affectivity Rating		Practice Question
	Immediate Test	Delayed Test	
A _g R _g F _g	4.62 1.66	4.62 1.77	.04 .20
A _g R _{ng} F _g	4.09 1.82	4.39 2.11	.10 .30
A _{ng} R _g F _g	4.53 1.64	4.56 1.64	.13 .34
A _{ng} R _{ng} F _g	3.80 1.97	4.52 1.88	.04 .20
A _g R _g F _{ng}	4.14 1.94	4.51 1.54	.10 .31
A _g R _{ng} F _{ng}	3.61 1.88	4.47 2.19	.20 .41
A _{ng} R _g F _{ng}	4.11 2.10	4.71 1.73	.28 .46
A _{ng} R _{ng} F _{ng}	4.63 1.58	4.43 1.74	.05 .21
Control (No Learning Experience)	3.75 2.07	3.56 1.57	.06 .22

Table 25

Summary of the Three-way Analysis of Variance for the Affectivity Rating on the Immediate Test of Learning and Transfer, and the Affectivity Rating and the Practice Question on the Delayed Test of Learning and Transfer

				Affectivity Rating		Practice Question			
				Immediate Test		Delayed Test			
Source	df	MS	F	df	MS	F	df	MS	F
Answer (A)	1	1.33	.40	1	.66	.19	1	.04	.39
Rule (R)	1	5.42	1.62	1	1.05	.31	1	.08	.76
Feedback (F)	1	1.06	.31	1	.28	.08	1	.32	3.22
A x R	1	2.45	.73	1	.32	.09	1	.63	6.16*
A x F	1	6.36	1.90	1	.23	.07	1	.01	.06
R x F	1	5.39	1.61	1	.32	.09	1	.06	.63
A x R x F	1	5.19	1.55	1	1.20	.36	1	.14	1.40
Error	212	3.35		180	3.39		180	.10	

* $p < .05$

Note: The total mean square was taken as the error term for the practice question (cf., Li, 1957).

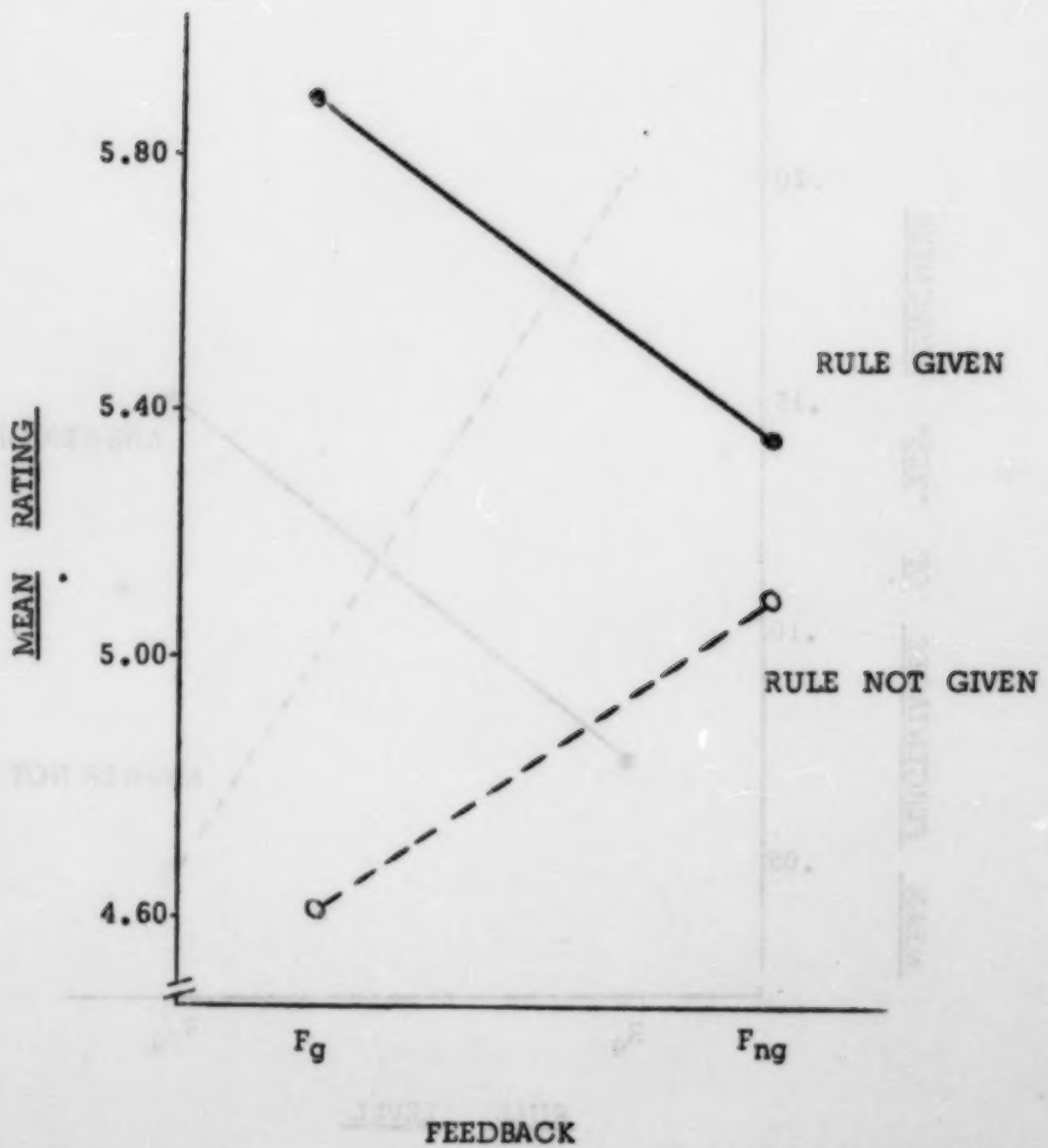


Figure 4. R x F Interaction. Profiles of Means for the Learning Lesson Motivational Rating Showing the Effect of Rules at Each Level of the Feedback Variable

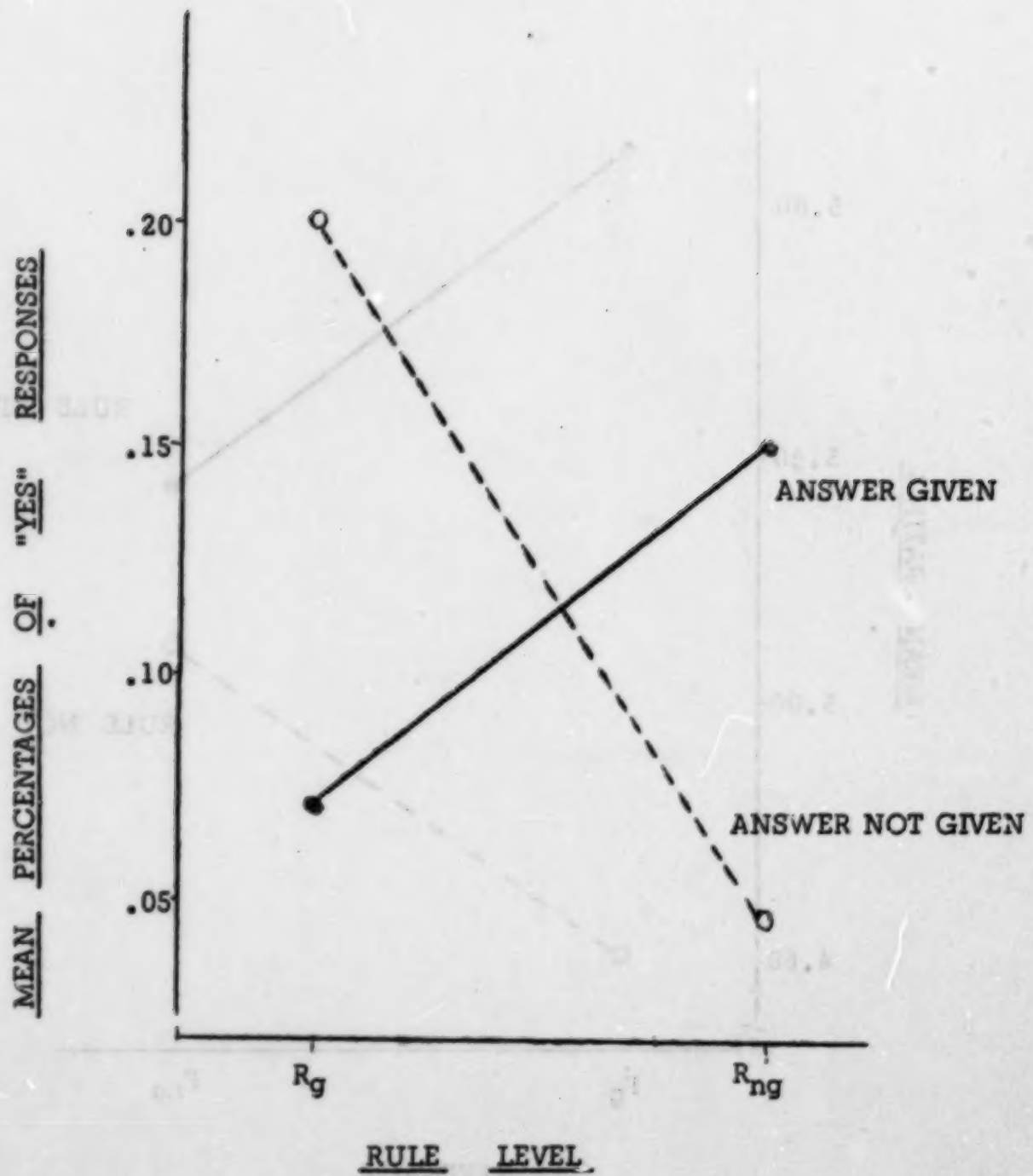


Figure 5. A x R Interaction. Profiles of Means for the Practice Question Showing the Effects of Answers at Each Level of the Rule Variable

and the A_gR_{ng} groups. This suggests that when learners were given an intermediate amount of information, interest was aroused and learners practiced outside of class hours more than learners who were given maximum or minimum amounts of information. This finding supports Kersh (1962, 1964) who found that his guided discovery procedure motivated learners to continue the learning experience beyond the formal period of learning.

Time. Subjects took between 5 and 30 minutes to finish the program. Subjects who were given minimal information took the longest time to finish.

On the learning program and the immediate test of learning and transfer, the answer variable produced reliable effects ($F = 13.29$, $p < .001$ for the former; $F = 9.12$, $p < .01$ for the latter), as shown by Tables 26 and 27. On the learning program, groups which were given answer prompts took less time to work through the program than groups which were not given answer prompts. However, on the immediate test, the advantage shifted to the groups that were not given answer prompts on the learning program. The groups which were required initially to solve cryptograms took less time on the test than the groups which were given answers as prompts.

On both the program and the immediate test, the rule variable was also important in producing reliable effects ($F = 99.35$, $p < .001$ for the former; $F = 14.78$, $p < .001$ for the latter). On the learning program, groups which were given rules took less time to work through the lesson than groups which were not given rules. However, the groups which were not given rules on the program took less time to take the immediate test than the groups which were given rules.

These findings, must be considered in light of test performance. The groups which were not given rules performed more poorly on the test of learning than the groups that were given rules. Therefore, even though less time was taken by the rule-not-given groups, the results indicate that these groups were not equipped with the information that enabled them to solve problems. Further, the fact that the groups which learned the most took the shortest time to learn make an interpretation of the data possible. If the groups that learned

Table 26

Treatment Group Means and Standard Deviations for the Time* to Take the Learning Lesson, and Immediate and Delayed Tests of Learning and Transfer

Treatment Group	Learning Lesson	Immediate Test	Delayed Test
A _g R _g F _g	10.33 2.04	21.83 5.22	16.96 8.38
A _g R _{ng} F _g	15.45 4.73	18.93 6.42	18.19 8.39
A _{ng} R _g F _g	11.62 4.22	17.97 5.66	17.78 8.05
A _{ng} R _{ng} F _g	17.29 4.88	16.36 4.68	18.12 9.20
A _g R _{ng} F _{ng}	9.09 2.69	22.55 6.35	20.95 6.91
A _g R _{ng} F _{ng}	13.71 5.42	19.21 7.64	19.76 7.12
A _{ng} R _g F _{ng}	10.47 3.53	21.53 6.08	18.80 9.01
A _{ng} R _{ng} F _{ng}	17.38 4.27	16.75 6.06	19.59 8.28
Control (No Learning Experience)	----- -----	32.77 8.20	20.48 6.74

* time is in minutes

Table 27

Summary of the Three-way Analysis of Variance for the Time to Take the Learning Lesson, and Immediate and Delayed Tests of Learning and Transfer

Source	Learning Lesson			Immediate Test			Delayed Test		
	df	MS	F	df	MS	F	df	MS	F
Answer (A)	1	226.41	13.29***	1	334.38	9.12**	1	26.84	.40
Rule (R)	1	1692.19	99.35***	1	541.82	14.78***	1	13.19	.19
Feedback (F)	1	55.51	3.26	1	83.50	2.28	1	70.44	1.04
A x R	1	27.32	1.60	1	.08	.00	1	20.45	.30
A x F	1	12.42	.73	1	30.40	.82	1	32.94	.49
R x F	1	1.92	.11	1	44.15	1.20	1	.05	.00
A x R x F	1	10.23	.60	1	25.63	.70	1	49.78	.73
Error	212	17.03		212	36.67		180	67.90	

** $p < .01$

*** $p < .001$

the most had also taken the longest time to learn, the interpretation of the results would have been difficult since it could be argued that time was the important factor in producing the enhanced learning.

Program Error Rate. In all experimental treatments, subjects recorded their answers to each question as they advanced through the lesson. These responses were scored as correct or incorrect according to the criteria mentioned in Chapter VI. A summary of the analysis of these error rates appears in Tables 28 and 29.

The answer variable produced a reliable effect on error rate ($F=11.32$, $p<.001$). The groups that were given answer prompts responded on the lesson with more correct answers than the groups that were not given answer prompts. This was to be expected as the answer-given groups had only to copy the correct response in the lesson. The reliable main effects of rule and feedback must be interpreted in light of the dependable rule x feedback interaction ($F=5.17$, $p<.05$). Examination of Figure 6 shows that giving rules increased the number of correct responses to a greater extent when feedback was not given than when feedback was given.

It was mentioned that giving answer prompts and feedback when rules were not given retarded performance on the delayed test of learning. On the learning program, giving feedback, as compared with not giving feedback, increased the number of correct responses when rules were not given. One interpretation these results suggest is that the effect of feedback in the retention situation, when rules were not given, was related more to the motivational factor of feedback than to the information factor. Subjects who received rules through feedback had the same information as subjects who received rules as prompts. Since performance was retarded for the $A R_g F_{ng}$ group, this retardation could not have been due to differences in information presented. This interpretation gains support from the dependable rule x feedback interaction for the learning program motivational rating. Another interpretation of these results is that it matters whether rules are presented before or after problems are worked.

Supplementary Three-way Analysis of Covariance. The question, "What effect do different types and amounts of information have on transfer when all subjects reach the same level of mastery of the

Table 28

Treatment Group Means and Standard Deviations for the Learning Lesson Error Rate

Treatment Group	Error Rate
$A_{gR}F_g$ $n = 30$	13.57 .82
$A_{gR_{ng}}F_g$ $n = 29$	13.03 1.35
$A_{ngR_g}F_g$ $n = 29$	12.69 1.54
$A_{ngR_{ng}}F_g$ $n = 28$	12.57 2.47
$A_{gR_g}F_{ng}$ $n = 22$	13.64 .90
$A_{gR_{ng}}F_{ng}$ $n = 28$	12.00 1.78
$A_{ngR_g}F_{ng}$ $n = 30$	12.47 1.74
$A_{ngR_{ng}}F_{ng}$ $n = 24$	11.25 2.83

Note: The means represent the number of correct responses out of 14 possible responses on the learning lesson..

Table 29

Summary of the Three-way Analysis of Variance for the Error Rate on the Learning Lesson

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Answer (A)	1	36.12	11.32***
Rule (R)	1	41.72	13.08***
Feedback (F)	1	21.40	6.71**
A x R	1	2.36	.74
A x F	1	1.14	.36
R x F	1	16.49	5.17*
A x R x F	1	.00	.00
Error	212	3.19	

* $p < .05$
 ** $p < .01$
 *** $p < .001$

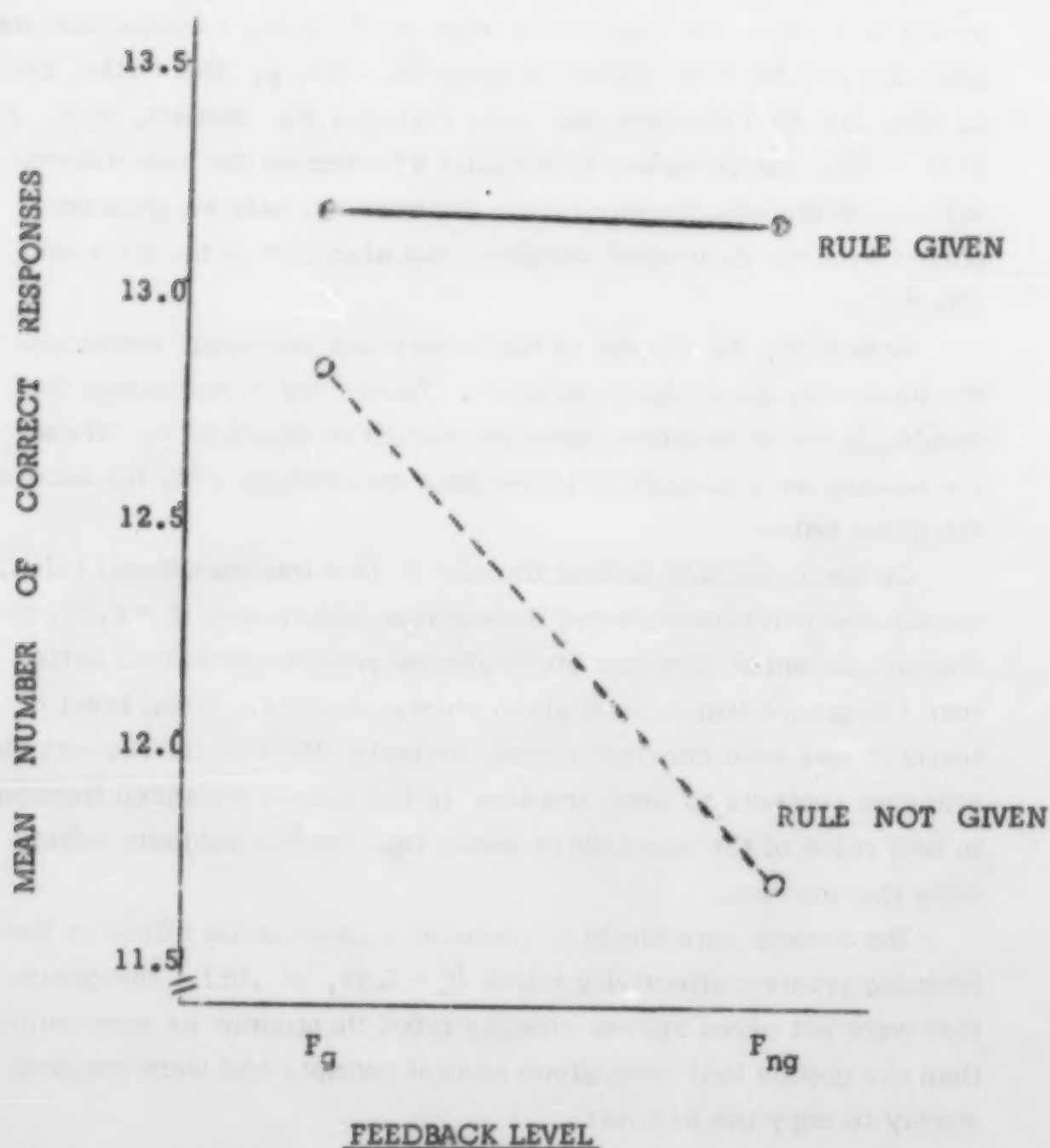


Figure 6. R x F Interaction. Profiles of Means for the Learning Lesson Error Rate Showing the Effect of Rules at Each Level of the Feedback Variable

subject matter?" is an important one to ask. Of the subjects who took the learning program and immediate test, not all reached the same level of performance on the learning test. To control statistically the effects of different levels of learning, an analysis of covariance was performed. In cases where the concomitant variate is influenced by the treatment, the analysis is appropriate if the experimenter interprets the results with caution (Lindquist, 1953, p. 334; Ostle, 1963, p. 439; 456-457; Cochran and Cox, 1950, p. 90; Bartlett, 1936, p. 488-491). When the covariate is actually affected by the experimental variables, the adjustment process removes not only an error component from the dependent variable, but also part of the treatment effect.

Generally, the results of the covariance technique supported the three-way analysis of variance. Tables which summarize the results of the covariance technique appear in Appendix A. Since the results were supportive rather than conflicting, only the exceptions are noted below.

On the immediate test of transfer to new transpositional rules, the answer variable produced dependable differences ($F = 6.03, p < .05$). The groups which were not given answer prompts performed better than the groups which were given answer prompts. When level of learning was held constant among subjects, the results suggest that allowing subjects to work problems in the lesson enhanced transfer to new rules of the same class better than having subjects merely copy the answers.

The answer variable also produced a dependable effect on the learning program affectivity rating ($F = 6.38, p < .05$). The groups that were not given answer prompts rated the program as more enjoyable than the groups that were given answer prompts and were required merely to copy the answers.

In summary, the findings of the analysis of covariance suggest that the results obtained from the analysis of variance were largely independent of the subjects' performance on the immediate test of learning, as long as the level of learning was high. On the immediate test of learning, the means of all experimental groups averaged above

2.40 out of a possible score of 3.00. The two exceptions noted are in line with the findings of a supplementary four-way analysis of variance reported below.

Supplementary Four-way Analysis of Variance with Achievement Level as a Variable

The primary function of this study was to investigate the main and interactional effects of prompts and feedback. In many studies, intellectual ability has been shown to interact with information variables (cf., Hovland, Lumsdaine, and Sheffield, 1949, pp. 147-175). The effects of prompting and feedback presumably are closely related to the student's ability to learn. For example, a learner of relatively low ability might be expected to benefit more from the presentation of both prompts and feedback than a learner of relatively high ability. Further, intellectual ability might be expected to influence the student's motivation toward the learning experience. Students of low ability might react favorably to a highly prompted lesson and react unfavorably to a lesson which withheld information. On the other hand, students of high ability might not be influenced by such variations in prompting. These relationships were of primary interest in this supplementary analysis.

An equivalent, comparable index of intellectual ability was not available from each of the schools used in the experiment. Further, administrative problems made it impossible to test all students with the same standardized measure. Therefore, it was decided to split the groups on the basis of the above-median and below-median scores on each of the three available measures of quantitative achievement that were obtained from the schools' files. A four-way analysis of variance with achievement level (L) as the fourth variable, was used to analyze the data.

Immediate Test of Learning and Transfer. Tables 30 and 31 summarize the results of the immediate tests of learning and transfer. The rule variable was again shown to produce dependable effects on the tests of learning and transfer to new examples. The rule variable was also shown to influence the scores on the transfer to new transpositional rules test ($F = 4.42, p < .05$). On all tests, the groups that were given rules performed better than the groups that were not

Table 30a

Treatment Group Means and Standard Deviations for Scores on the Immediate Test of Learning and Transfer for Learners with Below-median Quantitative Achievement Scores

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
$A_g R_g F_g$ $n = 16$	2.94 .25	1.88 1.15	1.75 1.00	.81 1.11
$A_g R_{ng} F_g$ $n = 15$	2.73 .46	1.53 1.19	1.27 1.22	.47 1.06
$A_{ng} R_g F_g$ $n = 12$	2.92 .29	2.08 1.00	2.33 .89	.58 .90
$A_{ng} R_{ng} F_g$ $n = 12$	2.75 .62	1.42 1.24	1.50 1.09	.50 .67
$A_g R_g F_{ng}$ $n = 13$	2.92 .28	2.08 1.04	1.85 1.07	.85 .90
$A_g R_{ng} F_{ng}$ $n = 17$	2.71 .69	1.06 1.03	1.65 1.11	.71 .99
$A_{ng} R_g F_{ng}$ $n = 16$	2.44 .81	1.81 1.17	1.81 .83	.88 1.02
$A_{ng} R_{ng} F_{ng}$ $n = 9$	1.89 .78	.67 1.12	1.67 1.00	.78 .97

Table 30b

Treatment Group Means and Standard Deviations for Scores on the Immediate Test of Learning and Transfer for Learners with Above-median Quantitative Achievement Scores

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
$A_{gR}F_g$ $n = 14$	2.86 .36	2.57 .94	2.14 1.10	.93 1.38
$A_{gR_{ng}}F_g$ $n = 14$	2.86 .36	2.00 1.36	2.29 .99	1.93 1.27
$A_{ngR_g}F_g$ $n = 17$	3.00 .00	2.47 1.01	2.71 .59	1.12 1.36
$A_{ngR_{ng}}F_g$ $n = 16$	2.88 .34	2.00 1.32	2.44 .89	1.25 1.34
$A_{gR_g}F_{ng}$ $n = 9$	3.00 .00	2.44 1.13	2.56 .73	1.67 1.41
$A_{gR_{ng}}F_{ng}$ $n = 11$	3.00 .00	1.91 1.38	2.18 1.17	.73 1.27
$A_{ngR_g}F_{ng}$ $n = 14$	2.86 .36	2.64 .74	2.29 .99	.93 1.21
$A_{ngR_{ng}}F_{ng}$ $n = 15$	2.73 .46	1.80 1.32	2.13 1.13	1.53 1.41

Table 31

Summary of the Four-way Analysis of Variance for the Scores on the Immediate Test of Learning and Transfer

Source	df	Learning		Transfer to New Examples		Transfer to New Transitional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	2.00	9.68**	.28	.21	1.19	1.19	.22	.16
Rule (R)	1	1.59	7.68**	25.86	19.83***	4.42	4.42*	.01	.01
Feedback (F)	1	1.58	7.63**	1.95	1.50	.07	.07	.19	.14
Achievement (L)	1	2.95	14.25***	23.36	17.91***	19.89	19.89***	16.84	12.36***
A x R	1	.37	1.76	.01	.00	.22	.22	1.19	.87
A x F	1	2.89	13.98***	.26	.20	2.87	2.87	.60	.44
A x L	1	.93	4.48*	.25	.19	.14	.14	.09	.06
R x F	1	.13	.62	1.84	1.41	.27	.27	1.35	.99
R x L	1	.65	3.15	.47	.36	.84	.84	1.77	1.30
F x L	1	1.58	7.66**	.91	.70	.24	.24	1.21	.89
A x R x F	1	.00	.00	.28	.21	.66	.66	9.63	7.06**
A x R x L	1	.05	.23	.32	.25	.01	.01	2.28	1.67
A x F x L	1	.44	2.12	.73	.56	.03	.03	.06	.04
R x F x L	1	.13	.63	.55	.43	1.56	1.56	2.27	1.67
A x R x F x L	1	.12	.55	.30	.23	.04	.04	5.72	4.20*
Error	1	.21		1.30		1.00		1.36	

* $P < .05$ ** $P < .01$ *** $P < .001$

given rules. In every case, achievement level failed to interact reliably with rule. Prompting learners with rules was necessary for adequate performance regardless of the level of the learner's quantitative achievement.

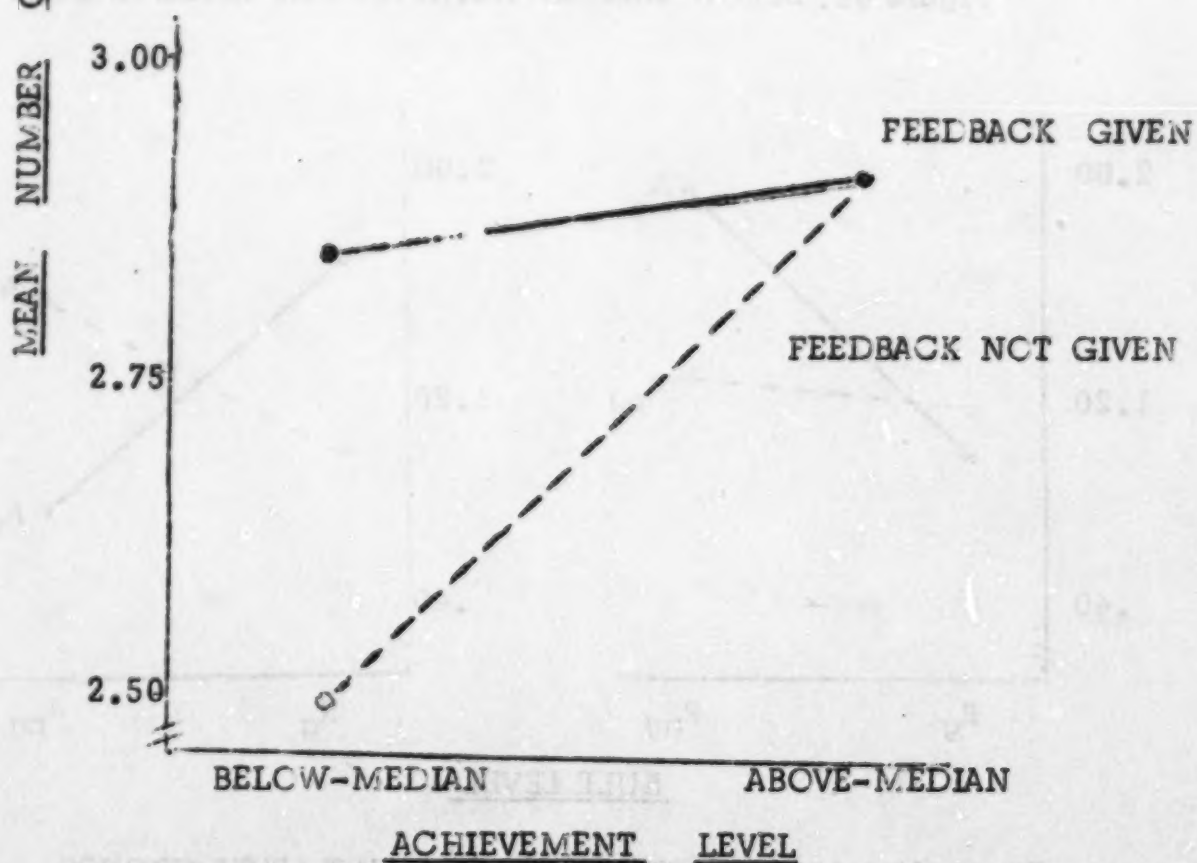
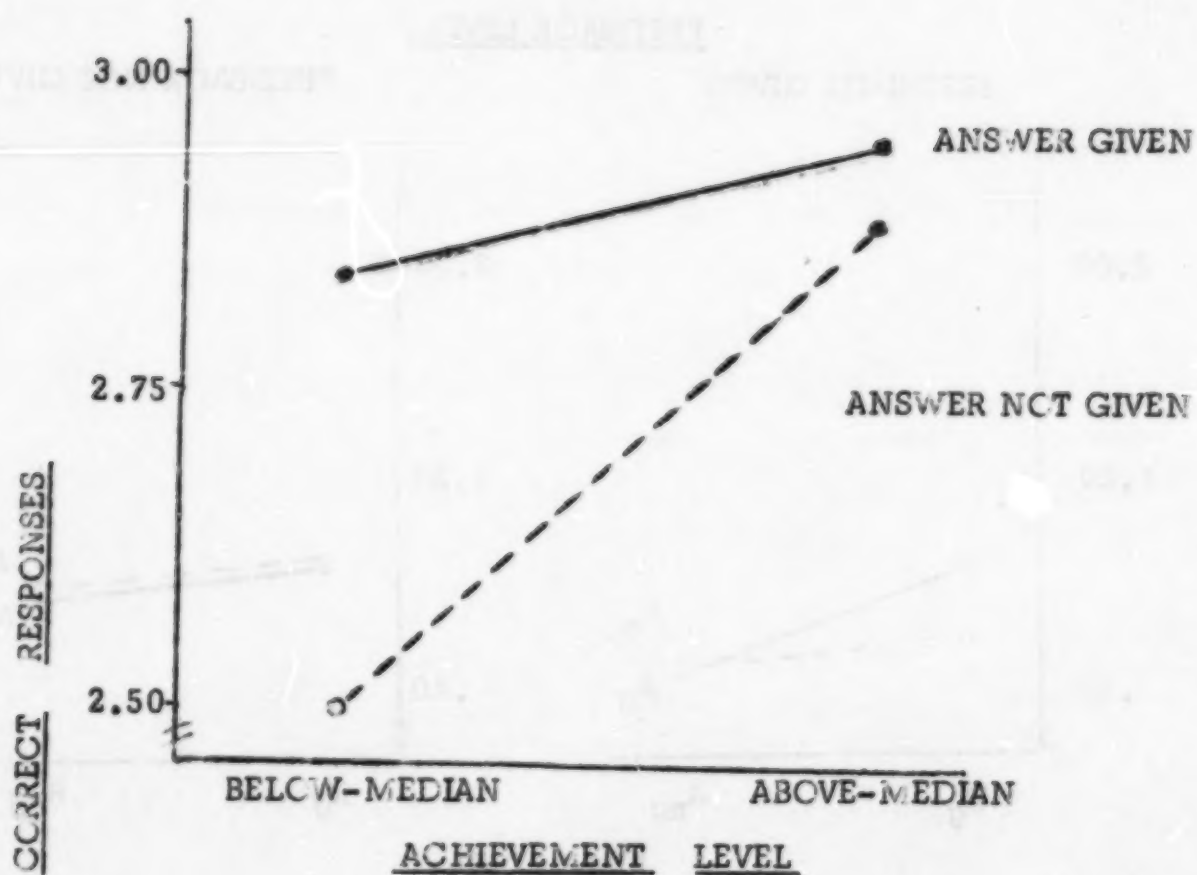
On the immediate test of learning, two interactions that involved achievement level were shown to be dependable. A third interaction between the answer and feedback variables was also dependable, and was discussed in a previous section. The answer variable as well as the feedback variable interacted with achievement level ($F = 4.98$, $p < .05$ for the former interaction; $F = 7.66$, $p < .01$ for the latter interaction.) Figures 7 and 8 reveal that only learners with below median quantitative achievement scores profited from the presentation of answers or feedback. In each case, when feedback or answers were withheld, the performance of the learners with below-median achievement scores was lower than that of the learners with above-median achievement scores. This is clear evidence of the importance of presenting maximum information for learners of low ability when the criteria is immediate recall of facts.

On the tests of transfer to new examples, and transfer to new transpositional rules, achievement level was shown to influence performance ($F = 17.91$, $p < .001$ for the former test; $F = 19.89$, $p < .001$ for the latter test). The above-median groups performed reliably better than the below-median groups. The results failed to show dependable interactions between achievement level and the variables of prompting or feedback.

On the immediate test of transfer to substitutional rules, the achievement level variable, as well as the $A \times R \times F$ and $A \times R \times F \times L$ interactions were shown to be dependable. Figure 9 reveals the nature of the dependable $A \times R \times F \times L$ interaction ($F = 4.20$, $p < .05$). When the below-median groups are considered, as shown by Figure 9a, no reliable differences were obtained. However, when the above-median groups are considered as shown by Figure 9b, answer and rule interactions were obtained which differed for each level of feedback. When feedback was given, the $A_{gng} R_{ng} F_g$ group performed dependably better than the other three groups ($p < .05$, Newman-Keuls

Figure 7
A x L Interaction. Profiles of Means for the Immediate Test of
Learning Showing the Effect of Answers at Each Level
of Achievement

Figure 8
F x L Interaction. Profiles of Means for the Immediate Test of
Learning Showing the Effect of Feedback at Each Level
of Achievement



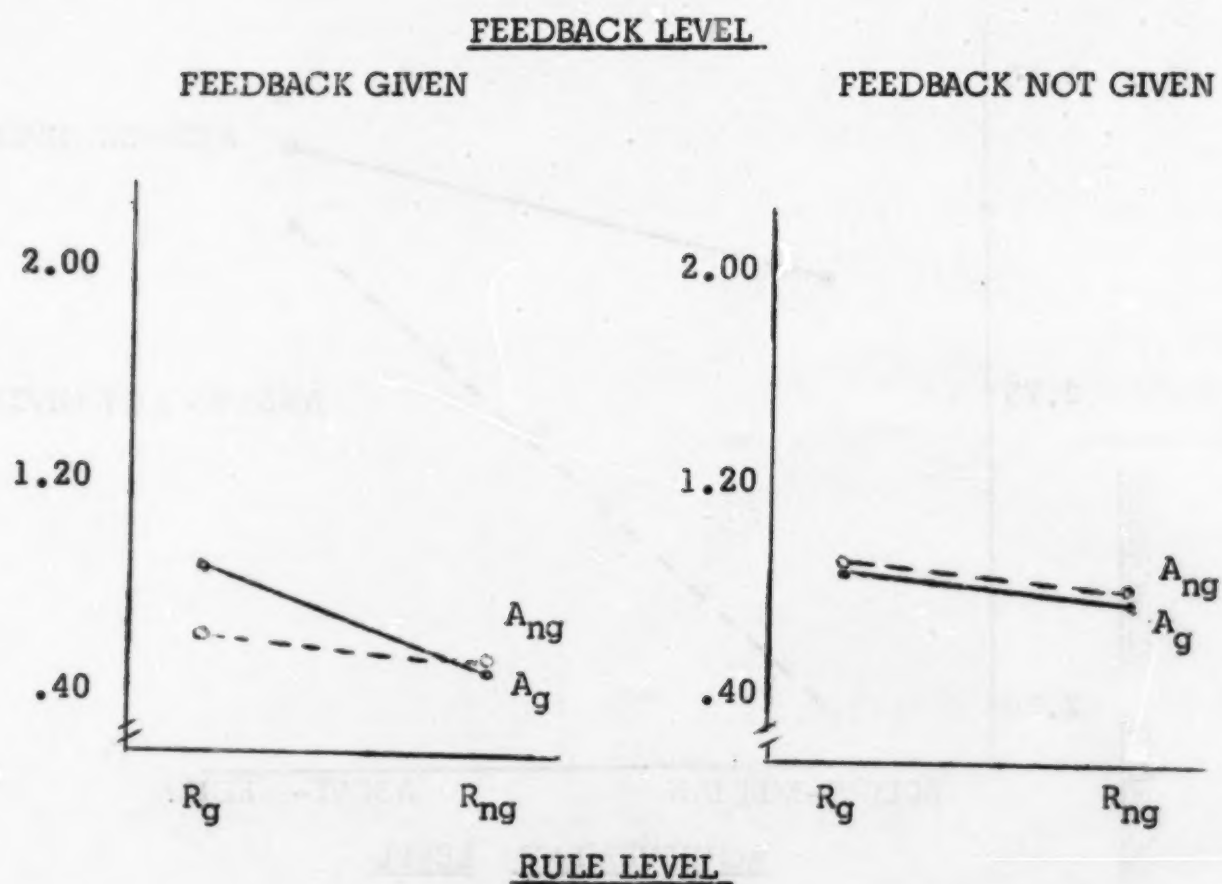


Figure 9a. BELOW-MEDIAN ACHIEVEMENT LEVEL GROUPS

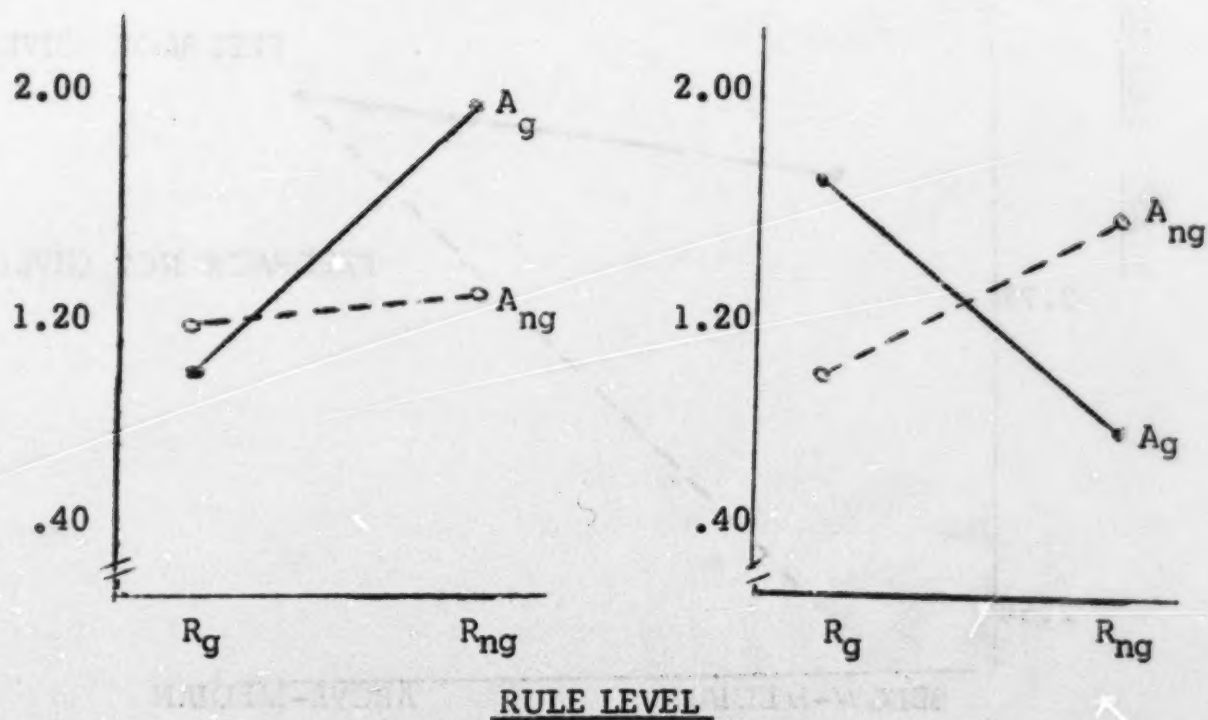


Figure 9b. ABOVE-MEDIAN ACHIEVEMENT LEVEL GROUPS

Figure 9. $A \times R \times F \times L$ Interaction. Profiles of Means for the Immediate Test of Transfer to Substitutional Rules Showing the Effect of Rules and Answers at Each Level of Feedback and Achievement

procedure). Oddly enough, the group whose performance on the delayed test of learning and motivation in the learning experience was retarded, performed best on the test of transfer to the new class of substitutional cryptograms.

When feedback was not given, the $A_{g g} R_{g g}$ groups' and the $A_{ng ng} R_{ng ng}$ groups' performance was reliably higher than the $A_{ng g}$ and the $A_{g ng} R_{g ng}$ groups' respectively. Apparently, for students of high achievement level, performance at working problems, which represented a concept of a different class than that taught, was enhanced by presenting either maximum information (answers, and rules in the form of prompts or feedback) or minimum information (no rules, answers or feedback). A possible explanation for this finding is that for students of high ability, presenting rules and answers as prompts for learning transpositional cryptograms established a situation which maximized the student's ability to discriminate between classes of cryptograms, i.e., transpositional and substitutional cryptograms. Further, withholding rules and answers, as well as feedback, caused learners of above-median achievement level not to be influenced by a set to use inappropriate transpositional concepts to solve substitutional problems. In other words, negative transfer was not increased by presenting maximum or minimum information.

Delayed Test of Learning and Transfer. Tables 32 and 33 summarize the results of the supplementary analysis for the delayed tests. The rule variable was shown to influence the scores on the delayed test of learning ($F = 6.53, p < .05$). The groups that were given rules scored higher than the groups that were not given rules. Hypothesis I was supported. The dependable main effect of achievement level must be interpreted in light of the reliable feedback x achievement level interaction ($F = 5.48, p < .05$). As was the case on the immediate test of learning, only those learners with below-median quantitative achievement scores profited from the presentation of feedback, as shown by Figure 10. When feedback was withheld, the performance of the low-achievement learners was retarded in comparison with the high-achievement learners. Hypothesis IV probably applies only to the subjects of below-median achievement.

Table 32a

Treatment Group Means and Standard Deviations for Scores on the Delayed Test of Learning and Transfer for Learners with Below-median Quantitative Achievement Scores

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
$A_{gR}F_{gF}$ $n = 13$	3.00 .00	2.00 1.00	2.08 .95	1.00 1.22
$A_{gR}F_{ngF}$ $n = 10$	2.70 .48	1.60 1.17	2.20 1.23	1.20 1.14
$A_{ngR}F_{gF}$ $n = 9$	2.89 .33	2.22 .97	2.44 1.01	.89 1.17
$A_{ngR}F_{ngF}$ $n = 11$	2.82 .40	1.73 1.35	1.82 1.25	.55 .52
$A_{gR}F_{gng}$ $n = 13$	2.62 .87	1.54 1.20	2.23 .73	1.46 1.39
$A_{gR}F_{ngng}$ $n = 14$	2.86 .36	1.00 1.24	2.21 .80	1.00 1.18
$A_{ngR}F_{gng}$ $n = 14$	2.71 .47	2.36 .93	2.00 1.11	1.21 1.12
$A_{ngR}F_{ngng}$ $n = 9$	2.11 .93	1.11 1.05	2.00 1.00	.78 .83

Table 32b

Treatment Group Means and Standard Deviations for Scores on the Delayed Test of Learning and Transfer for Learners with Above-median Quantitative Achievement Scores

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
A_{gRgFg} $n=13$	3.00 .00	2.54 .97	2.69 .63	2.23 1.24
A_{gRngFg} $n=11$	2.64 .50	2.09 1.14	2.82 .40	2.09 1.14
A_{ngRgFg} $n=14$	3.00 .00	2.50 .94	2.64 .84	1.57 1.22
$A_{ngRngFg}$ $n=15$	2.87 .35	2.13 1.19	2.60 .74	2.07 1.16
A_{gRgFng} $n=7$	2.86 .38	2.29 1.25	2.43 .98	2.00 1.41
$A_{gRngFng}$ $n=11$	2.91 .30	2.18 1.25	2.82 .40	1.45 1.37
$A_{ngRgFng}$ $n=11$	3.00 .00	2.45 .93	2.64 .81	2.00 1.18
$A_{ngRngFng}$ $n=13$	2.85 .38	2.00 1.15	2.54 .78	2.08 1.32

Table 33
Summary of the Four-way Analysis of Variance for Scores on the Delayed Test of Learning and Transfer

Source	df	MS	F	Transfer to New Examples		Transfer to New Substitutional Rules	
				MS	F	MS	F
Answer (A)	1	.07	.40	1.14	.92	.45	.59
Rule (R)	1	1.25	6.53*	11.58	9.37**	.02	.02
Feedback (F)	1	.71	3.69	2.50	2.02	.13	.17
Achievement (L)	1	1.40	7.34**	15.11	12.23***	12.39	16.22***
A x R	1	.59	3.10	.62	.50	.04	.05
A x F	1	.46	2.39	.22	.18	.04	.05
A x L	1	.64	3.33	1.17	.95	.01	.01
R x F	1	.12	.60	.28	.23	.34	.45
R x L	1	.01	.07	1.20	.97	.57	.74
F x L	1	1.05	5.48*	1.02	.82	.04	.05
A x R x F	1	.27	1.41	.26	.21	.15	.19
A x R x L	1	.00	.00	.04	.04	.50	.64
A x F x L	1	.18	.94	.25	.20	.28	.36
R x F x L	1	.10	.55	.92	.75	.06	.07
A x R x F x L	1	.29	1.50	.02	.02	.83	1.09
Error	172	.19		1.24		.76	

* $p < .05$
 * $p < .01$
 *** $p < .001$

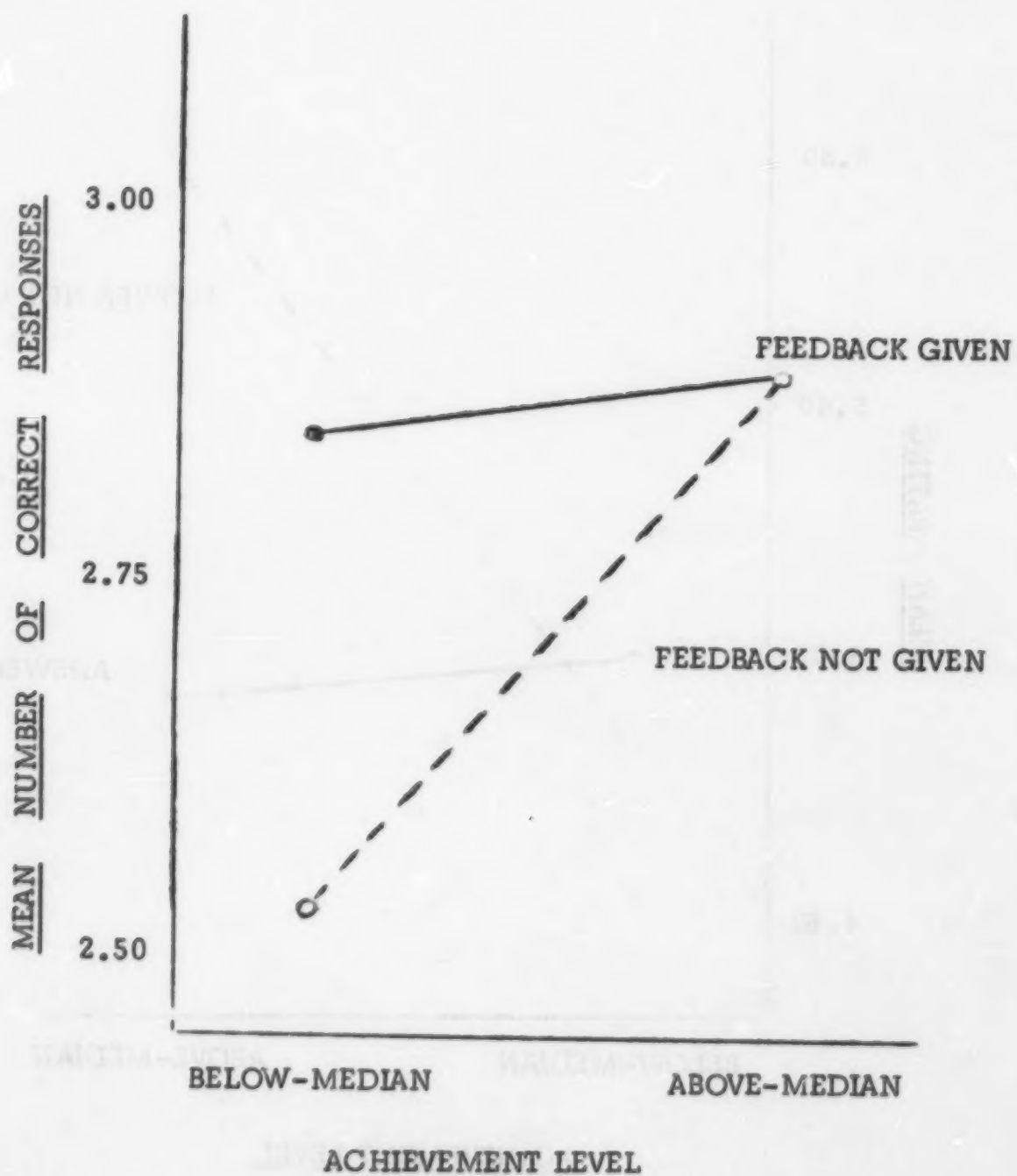


Figure 10. $F \times L$ Interaction. Profiles of Means for the Delayed Test of Learning Showing the Effect of Feedback at Each Level of Achievement

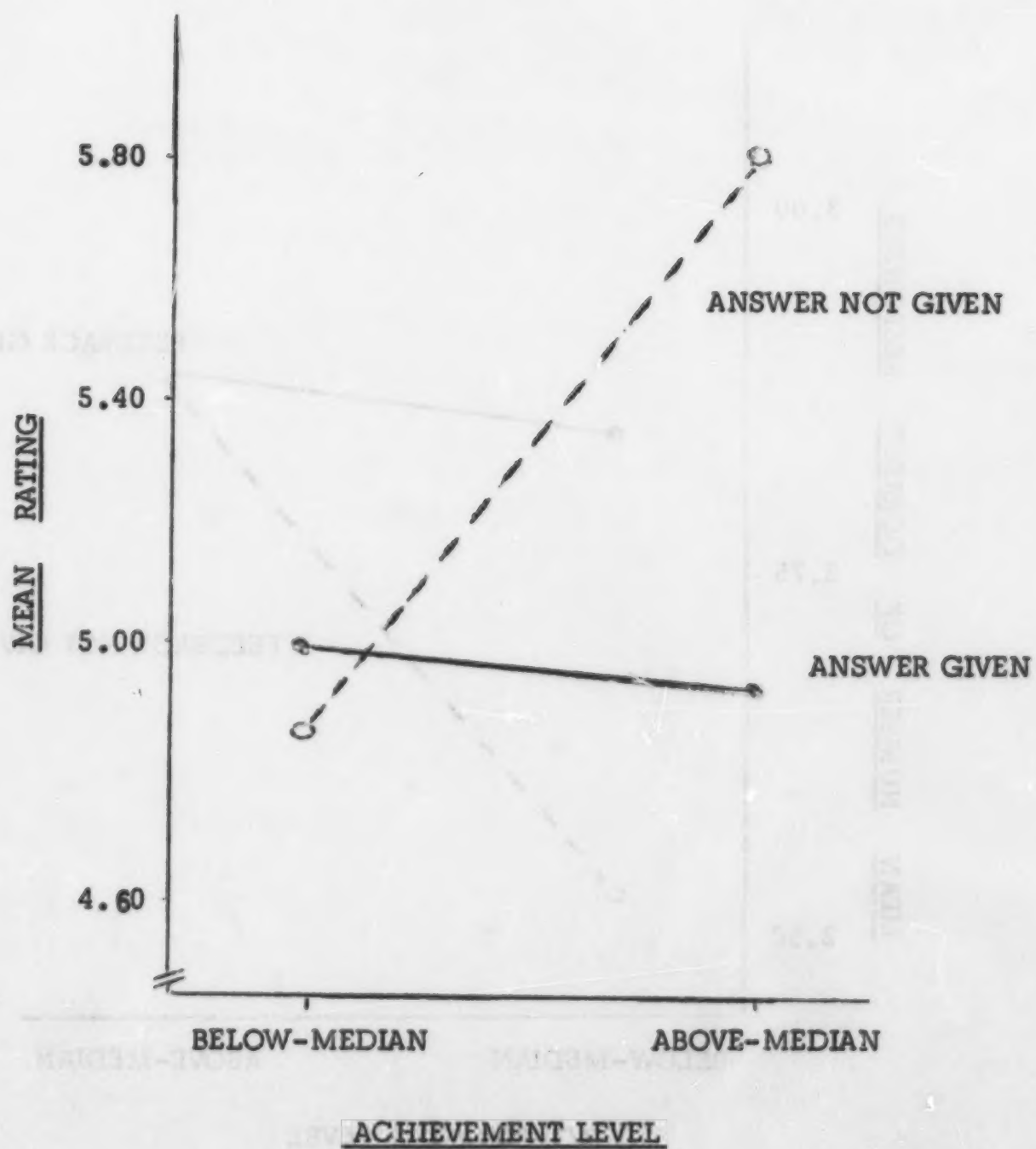


Figure 11. A x L Interaction. Profiles of Means for the Learning Lesson Affectivity Rating Showing the Effect of Answers at Each Level of Achievement

On the delayed test of transfer to new examples, the rule variable was reliable ($F=9.37$, $p<.01$) as well as the achievement level variable ($F=12.23$, $p<.001$). Groups that were given rules performed dependably better than groups that were not given rules, and high-achievement groups scored reliably higher than low-achievement groups. These results supplement the three-way analysis and suggest that it is important to give subjects rules in both feedback and non-feedback situations to enhance transfer to new examples.

On the delayed test of transfer to new transpositional rules and transfer to substitutional rules, the achievement level variable was reliable ($F=16.22$, $p<.001$ for the former test; $F=27.53$, $p<.001$ for the latter test.) Learners with above-median achievement scores performed better than learners with below-median achievement scores. The results failed to show dependable interactions between achievement level and the experimental variables.

Affectivity and Motivation Ratings for the Learning Program. As shown by Tables 34 and 35, a reliable interaction for the answer and achievement level variables was obtained for the affectivity ratings ($F=5.06$, $p<.05$). Figure 11 reveals that for students of above-median achievement scores, it was important to present unanswered examples in the learning lesson. This finding supplements the three-way analysis of variance and suggests that giving unanswered examples enhanced affectivity toward the learning experience only for learners with above-median scores on a quantitative achievement test. As was the case in the previous three-way analysis, the rule-given groups were found to rate the learning experience reliably higher than the rule-not-given groups ($F=13.81$, $p<.001$). For the motivation rating, the results supported the initial analysis. The results failed to show reliable interactions which involved achievement level.

PART II: RESULTS OF THE DERIVATION OF RULES TEST

Comparison of All Experimental Treatment Groups with the Control Group

To compare with chance the effectiveness of the learning lessons, Dunnett's procedure (cf, Winer, 1962, pp. 89-92) was used. (See

Table 34a

Treatment Group Means and Standard Deviations for the Affectivity and Motivational Ratings for the Learning Lesson for Learners with Below-median Quantitative Achievement Scores

Treatment Group	Affectivity Rating	Motivational Rating
A _g R _g F _g n = 16	5.56 1.93	6.13 1.20
A _g R _{ng} F _g n = 15	4.59 1.90	4.40 1.99
A _{ng} R _g F _g n = 12	5.17 1.80	6.13 1.57
A _{ng} R _{ng} F _g n = 12	4.83 1.03	4.33 1.92
A _g R _g F _{ng} n = 13	5.54 1.85	5.46 2.11
A _g R _{ng} F _{ng} n = 17	4.29 1.69	5.15 2.06
A _{ng} R _g F _{ng} n = 16	5.35 1.62	4.86 2.07
A _{ng} R _{ng} F _{ng} n = 9	4.06 1.67	5.22 1.56

Table 34b

Treatment Group Means and Standard Deviations for the Affectivity and Motivational Ratings for the Learning Lesson for Learners with Above-median Quantitative Achievement Scores

Treatment Group	Affectivity Rating	Motivational Rating
A _g R _g F _g <u>n</u> = 14	5.75 1.65	5.57 1.65
A _g R _{ng} F _g <u>n</u> = 14	4.85 1.48	4.43 2.06
A _{ng} R _{ng} F _g <u>n</u> = 17	6.06 .97	5.74 1.37
A _{ng} R _{ng} F _{ng} <u>n</u> = 16	6.00 1.10	5.11 2.08
A _g R _g F _{ng} <u>n</u> = 9	5.11 .93	5.36 1.67
A _g R _{ng} F _{ng} <u>n</u> = 11	4.00 2.28	5.09 1.45
A _{ng} R _g F _{ng} <u>n</u> = 14	5.86 1.66	5.71 1.59
A _{ng} R _{ng} F _{ng} <u>n</u> = 15	5.20 1.57	4.93 1.71

Table 35
Summary of the Four-way Analysis of Variance for the Affectivity and Motivational Ratings for the Learning Lesson

Affectivity Rating				Motivational Rating			
Source	df	MS	F	df	MS	F	
Answer (A)	1	6.61	2.56	1	.17	.05	
Rule (R)	1	35.74	13.81***	1	32.57	10.17**	
Feedback (F)	1	9.56	3.70	1	.00	.00	
Achievement (L)	1	9.78	3.78	1	.06	.02	
A x R	1	1.09	.42	1	2.52	.78	
A x F	1	.03	.01	1	1.02	.32	
A x L	1	13.10	5.06*	1	2.24	.70	
R x F	1	3.43	1.33	1	15.21	4.75*	
R x L	1	1.03	.40	1	.36	.11	
F x L	1	2.06	.80	1	.24	.07	
A x R x F	1	.24	.10	1	1.78	.56	
A x R x L	1	.07	.03	1	.61	.19	
A x F x L	1	.48	.19	1	.03	.01	
R x F x L	1	.15	.06	1	6.71	2.09	
A x R x F x L	1	.08	.03	1	2.63	.82	
Error	204	2.59		204	3.20		

* $p < .05$
 ** $p < .01$
 *** $p < .001$

Tables 36 and 37). On the immediate and delayed tests of learning, the two experimental groups which received rules scored reliably higher than the control group ($p < .05$). On the immediate test of transfer to new examples, giving rules, compared with withholding rules, also resulted in above-chance performance for the same two groups. On the delayed test of transfer to new examples, only the rule given, answer given group performed reliably better than the control group. These results indicate that the training increased subjects' ability to derive rules only when rules were initially given in the learning lesson. Apparently, a procedure which from the beginning of training, requires subjects to derive rules for themselves does not offer sufficient information. These findings also indicate that further analysis of the data is appropriate.

Two-way Analysis of Variance

Immediate Test of Learning and Transfer. Tables 38 and 39 show that the rule variable produced a reliable effect on the learning test scores ($F = 23.94$, $p < .001$). The groups that were initially given rules relevant to solving the transpositional cryptograms in the lesson scored higher than the groups that were required to derive the rules for themselves. The rule variable also produced a dependable effect on the test of transfer to new examples ($F = 28.46$, $p < .001$), on the test of transfer to new transpositional rules ($F = 8.47$, $p < .001$), and on the test of transfer to substitutional rules ($F = 4.95$, $p < .05$). In every case, the groups which were given rules scored higher on the deriving-rules test than the groups that were required to derive the rule for themselves in the lesson.

The answer variable was not an important factor in test performance. Apparently, for optimal learning and transfer, giving rules provides information which the learner needs to perform. By learning to generalize within the class of transpositional rules, one may learn to mediate a discrimination between transposition cryptograms and other kinds of cryptograms. Simple practice, from the very beginning of the lesson, at deriving rules was not the best condition for learning and transfer.

Delayed Test of Learning and Transfer. On the delayed test of learn-

ing and transfer to new examples, the rule variable produced dependable effects in favor of the rule-given groups ($F=18.35$, $p<.001$ for the learning test; $F=18.56$, $p<.001$ for the transfer test). The importance was again shown.

Affectivity Ratings. Tables 40, 41, 42, and 43 summarize the results for the affectivity and motivational measures. The rule variable produced reliable effects on the learning lesson and immediate test affectivity ratings ($F=8.55$, $p<.01$ for the former; $F=4.63$, $p<.05$ for the latter). The groups that were given rules rated the lesson and immediate test as more enjoyable than the groups that were not given rules. These results support those of the problem-solving test, and suggest that giving rules to secondary school students makes the learning experience more enjoyable than requiring the students to discover for themselves the rules involved. The results failed to show reliable effects for the learning lesson motivational rating or the practice question.

Time. Tables 44 and 45 on the learning lesson show that, the answer variable produced reliable effects ($F=6.93$, $p .05$). Groups that were given answers took less time than the groups that were not given answers. The rule variable also produced reliable effects ($F = 42.32$, $p<.001$), in favor of the rule-given groups. The groups that took the shortest time to learn performed best on the immediate and delayed tests. Interpretation of the results is possible since it can not be argued that time was the important factor in producing enhanced performance.

Lesson Error Rate. Tables 46 and 47 show that the answer variable produced a reliable effect on error rate ($F = 8.11$, $p<.01$). The groups that were given answers responded with more correct answers on the lesson than groups that were not given answers. Further, the rule variable produced a reliable effect ($F = 41.33$, $p<.001$) in favor of the rule-given groups. Apparently, for optimal performance on responding in a learning situation, giving maximum information which requires only that Ss copy responses is superior to giving partial information that requires Ss to construct answers.

Supplementary Two-way Analysis of Covariance. To control statistically the effects on retention and transfer of different levels of learning, an analysis of covariance was performed. It should be recalled that when the covariate is actually affected by the experimental variables, as is the case in this analysis, the adjustment process removes not only an error component from the dependent variable, but also part of the treatment effect. Tables which summarize results of the covariance technique appear in Appendix B. This analysis was performed to find if any differences in transfer would remain after differences in learning had been statistically controlled.

On the immediate test of transfer to new examples, the rule variable produced a reliable effect when learning was statistically controlled ($F = 5.40, p < .01$). The groups which were given rules still scored higher than the groups that were not given rules. The results failed to support the analysis of variance findings on the other tests of retention and transfer. On these latter tests, the effects of the rule variable were not independent of the initial level of learning. That is, on tests of transfer to new rules, the higher performance of the rule-given groups was related to the higher performance on the immediate test of learning.

The results failed to show dependable effects on the affectivity and motivational measures when initial level of learning was held constant.

Supplementary Three-way Analysis of Variance with Achievement Level as a Variable. To find if the above results hold of learners of differing ability levels, a three-way analysis of variance with achievement level as a variable was performed. Tables 48 and 49 summarize the results of the immediate tests of learning and transfer. The rule variable was again shown to produce reliable effects on all of the immediate tests. On all delayed tests, the groups that were given rules performed better than learners of lower ability on all delayed tests.

Affectivity Rating. Tables 52 and 53 reveal that the rule variable affected affectivity toward the learning experience as more enjoyable than groups that were required to derive the rules for themselves.

Table 36

Summary of the Comparison of All Experimental Treatment Group Means with the Control Group
 Mean for the Delayed Test of Group Learning and Transfer

	Learning			Transfer to New Examples			Transfer to New Transpositional Rules			Transfer to New Substitutional Rules		
	Mean	D	t	Mean	D	t	Mean	D	t	Mean	D	t
1	2.00	1.54	4.97*	1.83	1.37	4.42*	2.17	.38	1.41	2.17	.13	.41
2	1.13	.67	2.16	.88	.42	1.35	1.79	.00	.00	1.75	-.29	-.91
3	2.14	1.68	5.42*	2.14	1.68	5.42*	2.32	.53	1.96	2.23	.19	.59
4	.76	.30	.97	.56	.10	.32	1.56	-.23	-.74	1.64	-.40	-1.25
Control	.46			.46			1.79			2.04		
	(F3 11.63, $p < .001$)			(F= 11.58, $p < .001$)			(F= 2.60, $p < .05$)			(F= 12.27, $p < .05$)		

Note 1: The symbol D refers to the difference between each experimental group mean and the control group mean

Note 2: The F ratio shown for each test represents a one-way analysis of variance which includes the eight experimental groups and one control group

Note 3: An asterisk indicates that the control group mean differed reliably from the particular experimental group mean, $p < .05$, two-tailed, as determined by Dunnett's procedure.

Table 37

Summary of the Comparison of All Experimental Treatment Group Means with the Control Group
Mean for the Delayed Test of Learning and Transfer Procedure

Learning	Transfer to New Examples				Transfer to New Transpositional Rules				Transfer to New Substitutional Rules			
	<u>Mean</u>	<u>D</u>	<u>t</u>	<u>Mean</u>	<u>D</u>	<u>t</u>	<u>Mean</u>	<u>D</u>	<u>Mean</u>	<u>D</u>	<u>t</u>	<u>t</u>
1.	2.17	1.46	4.06*	2.17	1.65	4.46*	2.29	.00	2.67	-.10	.34	
2.	1.05	.34	.94	1.10	.58	1.57	2.14	-.15	2.10	-.47	-1.62	
3.	2.35	1.64	4.56*	2.40	1.88	.51	2.55	.26	2.35	-.22	-.76	
4.	1.26	.55	1.53	1.11	.59	1.59	2.32	.03	2.47	-.10	-.34	
Control	.71			.52			2.29		2.57			

($F = 8.17, p < .001$) ($F = 9.31, p < .001$) ($F = .68, p < .05$) ($F = 1.25, p < .05$)

Note 1: The symbol D refers to the difference between each experimental group mean and the control group mean

Note 2: The F ratio shown for each test represents a one-way analysis of variance which includes the eight experimental groups and one control group

Note 3: An asterisk indicates that the control group mean differed reliably from the particular experimental group mean, $p < .05$, two-tailed, as determined by Dunnett's procedure.

Table 38

Treatment Group Means and Standard Deviations for Scores on the Immediate Test and the Delayed Test of Learning and Transfer

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
<u>Immediate Test</u>				
AgRg n = 29	2.00 1.22	1.83 1.28	2.17 .97	2.17 1.04
AgRng n = 24	1.13 1.19	.88 1.26	1.79 .93	1.75 1.15
AngRg n = 22	2.14 1.13	2.14 1.25	2.32 .84	2.23 .07
AngRng n = 25	.76 1.01	.56 .87	1.56 1.12	1.64 1.25
Control n = 24	.46 .78	.46 .72	1.79 .83	2.04 1.20
<u>Delayed Test</u>				
AgRg n = 24	2.17 1.13	2.17 1.27	2.29 1.00	2.67 .76
AgRng n = 21	1.05 1.32	1.10 1.34	2.14 .91	2.10 1.04
AngRg n = 20	2.35 1.04	2.40 1.05	2.55 .69	2.35 1.10
AngRng n = 19	1.26 1.19	1.11 1.33	2.32 .75	2.47 1.02
Control n = 21	.71 1.06	.52 .93	2.29 .56	2.57 .68

Table 39

Summary of the Two-way Analysis of Variance for Scores on the Immediate Test and Delayed Test of Learning and Transfer

Learning				Transfer to New Examples		Transfer to New Transpositional Rules		Transfer to Substitutional Rules	
Source	df	MS	F	Immediate Test					
				MS	F	MS	F	MS	F
Answer (A)	1	.32	.35	.00	.00	.05	.05	.02	.01
Rule (R)	1	31.36	23.94***	39.58	28.46***	8.03	8.47**	6.31	4.95*
A x R	1	1.55	1.19	2.41	1.73	.88	.93	.17	.13
Error	96	1.31		1.39		.95		1.27	107
Source	df	MS	F	Delayed Test					
				MS	F	MS	F	MS	F
Answer (A)	1	.83	.60	.31	.30	.96	1.32	.02	.02
Rule(R)	1	25.35	18.35***	29.18	18.56***	.76	1.04	1.04	1.09
A x R	1	---	.00	.26	.17	.03	.05	2.52	2.52
Error	80	1.38		1.57		.73		.96	

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 40

Treatment Group Means and Standard Deviations for Affectivity and Motivational Ratings for the Learning Lesson

Treatment Group	Affectivity Ratings	Motivational Ratings
$A_g R_g$ $n = 29$	5.20 1.81	4.99 2.24
$A_g R_{ng}$ $n = 24$	4.60 1.54	4.82 2.12
$A_{ng} R_g$ $n = 22$	5.76 1.50	5.62 1.63
$A_{ng} R_{ng}$ $n = 25$	4.53 1.29	4.98 1.54

Table 41

Treatment Group Means and Standard Deviations for the Affectivity Rating on the Immediate Tests of Learning and Transfer, and Affectivity Rating and Practice Question on the Delayed Tests of Learning and Transfer

Treatment Group	Affectivity Rating		Practice Question
	Immediate Test	Delayed Test	
$A_g R_g$	4.63 1.85	4.54 1.66	.13 .34
$A_g R_{ng}$	4.27 1.74	3.76 1.84	.05 .21
$A_{ng} R_g$	4.97 1.95	5.21 1.54	.10 .31
$A_{ng} R_{ng}$	3.80 1.51	4.46 1.93	.21 .42

Table 42
Summary of the Two-way Analysis of Variance, Affectivity and Motivational Ratings for the Learning Lesson

Affectivity Rating			Motivational Rating		
Source	df	MS	F	df	F
Answer (A)	1	1.47	.60	1	1.05
Rule (R)	1	20.76	8.55**	1	1.08
A x R	1	2.53	1.04	1	.37
Error	96	2.43		96	3.72

Table 43
Summary of the Two-way Analysis of Variance for the Affectivity Rating on the Immediate Tests of Learning and Transfer, and the Affectivity Ratings and Practice Question on the Delayed Test of Learning and Transfer

Affectivity Rating			Delayed Test			Practice Question		
Immediate Test								
Source	df	MS	F	df	MS	F	df	MS
Answer (A)	1	.11	.04	1	9.76	3.21	1	.09
Rule (R)	1	14.45	4.63*	1	12.00	3.94	1	.01
A x R	1	4.04	1.29	1	.01	-----	1	.18
Error	96	3.12		80	3.04		80	.11

* $p < .05$ ** $p < .01$

Table 44

Treatment Group Means and Standard Deviations for Time on the Learning Lesson, Immediate and Delayed Tests of Learning and Transfer

Treatment Group	Learning Lesson	Immediate Test	Delayed Test
A_{gR_g}	9.59 3.92	16.79 7.18	15.67 7.77
$A_{gR_{ng}}$	14.58 4.67	17.21 3.46	14.24 6.93
A_{ngR_g}	10.86 2.75	20.41 3.83	16.10 5.60
$A_{ngR_{ng}}$	18.36 6.77	17.76 8.13	17.00 6.24
Control (No Learning Experience)	----- -----	30.04 15.36	16.05 7.05

Table 45

Summary of the Two-way Analysis of Variance for Time on the Learning Lesson, Immediate and Delayed Tests of Learning and Transfer

Source	Learning Lesson				Immediate Test			Delayed Test		
	df	MS	F	df	MS	F	df	MS	F	
Answer (A)	1	158.06	6.93*	1	107.48	2.86	1	53.20	1.17	
Rule (R)	1	965.86	42.32***	1	30.88	.82	1	1.46	.03	III
A x R	1	---	1.69	1	58.10	1.54	1	28.26	.62	
Error	96	22.82		96	37.61		80	45.59		

* $p < .05$ *** $p < .001$

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Table 46

Treatment Group Means and Standard Deviations for the Learning Lesson

Treatment Group	<u>M</u>	<u>SD</u>
A _g R _g N=29	13.55	.07
A _g R _{ng} N=24	11.42	2.21
A _{ng} R _g N=22	12.82	1.59
A _{ng} R _{ng} N=25	9.92	2.72

Table 47

Summary of the Two-way Analysis of Variance for the Learning Lesson

<u>Source</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Answer (A)	1	30.78	8.11**
Rule (R)	1	156.76	41.33***
A x R	1	3.60	.95
Error	96	3379	

**p<.01

***p<.001

Table 48

Treatment Group Means and Standard Deviations for Scores on the Immediate Test of Learning and Transfer for Learners with Above- and Below-median Quantitative Achievement Test Scores

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
<u>Below-Median</u>				
$A_g R_g$ $\underline{n} = 18$	2.11 1.18	1.61 1.29	1.89 1.02	1.94 1.06
$A_g R_{ng}$ $\underline{n} = 13$	.77 .93	.46 .97	1.46 .88	1.38 1.12
$A_{ng} R_g$ $\underline{n} = 9$	1.67 1.32	1.67 1.41	1.78 .97	1.67 1.32
$A_{ng} R_{ng}$ $\underline{n} = 10$	.40 1.32	.30 .67	1.10 1.20	1.10 1.20
<u>Above-Median</u>				
$A_g R_g$ $\underline{n} = 11$	1.82 1.33	2.18 1.25	2.64 .67	2.55 .93
$A_g R_{ng}$ $\underline{n} = 11$	1.55 1.37	1.36 1.43	2.18 .87	2.18 1.09
$A_{ng} R_g$ $\underline{n} = 13$	2.46 .88	2.46 1.05	2.69 .48	2.62 .65
$A_{ng} R_{ng}$ $\underline{n} = 15$	1.00 1.00	.73 .96	1.87 .99	2.00 1.20

Table 49

Summary of the Three-way Analysis of Variance for Scores on the Immediate Test of Learning and Transfer

Source	df	Learning		Transfer to New Examples		Transfer to New Transitional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	.77	.61	.32	.24	.80	.97	.68	.59
Rule (R)	1	28.19	22.34***	38.32	28.90***	8.50	10.28**	6.63	5.73*
Ability (L)	1	5.27	4.18*	10.91	8.23**	14.82	17.91***	15.76	13.63***
A x R	1	1.85	1.47	1.90	1.43	.58	.70	.10	.09
A x L	1	1.24	.98	.09	.07	.07	.08	.31	.26
R x L	1	1.14	.91	.00	.00	.04	.06	.03	.03
A x R x L	1	2.39	1.89	.72	.54	.02	.03	.09	.07
Error	92	1.26*		1.33		.83		1.16	

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 50

Treatment Group Means and Standard Deviations for Scores on the Delayed Tests of Learning and Transfer for Learners with Above- and Below-Median Quantitative Achievement Test Scores

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
<u>Below-Median</u>				
$A_g R_g$ $n = 14$	1.64 1.22	1.79 1.40	1.93 1.14	2.43 .94
$A_g R_{ng}$ $n = 12$	.42 .90	.50 1.00	1.75 .97	1.83 1.19
$A_{ng} R_g$ $n = 8$	1.63 1.30	1.88 1.36	2.13 .83	1.88 1.34
$A_{ng} R_{ng}$ $n = 8$	.75 1.16	.88 1.36	2.13 .99	2.63 1.06
<u>Above-Median</u>				
$A_g R_g$ $n = 10$	2.90 .32	2.70 .67	2.80 .42	3.00 .00
$A_g R_{ng}$ $n = 9$	1.89 1.36	1.89 1.36	2.67 .50	2.44 .73
$A_{ng} R_g$ $n = 12$	2.83 .39	2.75 .62	2.83 .39	2.67 .78
$A_{ng} R_{ng}$ $n = 11$	1.64 1.12	1.27 1.35	2.45 .52	2.36 1.03

Table 51

Summary of the Three-way Analysis of Variance for Scores on the Delayed Test of Learning and Transfer

Source	df	Learning		Transfer to New Examples		Transfer to New Transitional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	.00	.00	.01	.01	.19	.32	.04	.04
Rule (R)	1	23.50	22.47***	26.48	18.89***	.61	.98	.63	.69
Ability (L)	1	29.45	28.15***	16.18	11.55**	10.11	16.37***	3.71	4.07*
A x R	1	.03	.03	.18	.13	.01	.01	3.23	3.54
A x L	1	.50	.49	1.34	.96	.71	1.15	.54	.59
R x L	1	.01	.01	.00	.00	.14	.23	1.30	1.43
A x R x L	1	.36	.35	1.13	.82	.23	.37	1.51	1.66
Error	92	1.05		1.40		.62		.91	

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 52

Treatment Group Means and Standard Deviations for Affectivity and Motivational Ratings on the Learning Lesson for Learners with Above- and Below-median Quantitative Achievement Test Scores

Treatment Group	Affectivity Ratings	Motivational Ratings
<u>Below-Median Learners</u>		
A_gR_g $n = 18$	5.41 1.86	5.17 2.30
A_gR_{ng} $n = 13$	4.46 1.71	5.35 2.20
$A_{ng}R_g$ $n = 9$	5.87 2.08	5.51 2.38
$A_{ng}R_{ng}$ $n = 10$	4.45 1.46	5.50 1.35
<u>Above-Median Learners</u>		
A_gR_g $n = 11$	4.85 1.74	4.68 2.22
A_gR_{ng} $n = 11$	4.77 1.37	4.18 1.94
$A_{ng}R_g$ $n = 13$	5.69 1.03	5.69 .95
$A_{ng}R_{ng}$ $n = 15$	4.58 1.21	4.63 1.61

Table 53

Summary of the Three-way Analysis of Variance for the Affectivity and Motivational Ratings for the Learning Lesson

Affectivity Rating					Motivational Rating				
Source	df	MS	F		df	MS	F		
Answer (A)	1	1.79	.71		1	5.67	1.52		
Rule (R)	1	18.91	7.56**		1	2.88	.77		
Ability (L)	1	.14	.06		1	8.25	2.21		
A x R	1	3.37	1.35		1	.85	.23		
A x L	1	.07	.03		1	1.43	.38		
R x L	1	2.11	.84		1	4.47	1.20		
A x R x L	1	.50	.20		1	.20	.05		
Error	92	2.50			92	3.73			

** $p < .01$

The achievement level factor failed reliably to affect affectivity.

Comments and Special Problems

In the project proposal, a stratified random sampling technique was specified, with aptitude or achievement measures to be used as the stratifying variables. In Experiment II, as described above, three different school systems were used to represent several different socio-economic levels in the greater Los Angeles area. This was done to increase the generalizability of the findings. Unfortunately, each of the several school systems provided different measures of quantitative and verbal achievement. Also, each of the school systems had its own rigidly specified testing program and would allow no further testing by the experimenters. Therefore a random, rather than a stratified random assignment, was used to determine the composition of the treatment groups. As a further precaution, the learning and transfer scores in this experiment were compared by schools. There were no particularly divergent means due to the schools factor.

It was not feasible to give pretests to all subjects as we had originally planned. The pretests, which were given in a pilot study, were difficult because the subjects knew nothing about deciphering cryptograms. The major result was that they were frustrated and antagonized by the materials. This initial contact with the materials seemed to jeopardize the entire pilot study. Therefore, it was felt better that the pretests not be given to the subjects.

Although we were using individual teaching machines, it was still possible that students would communicate information to one another during the experiment. The proposal specified that many different rules and examples would be used to reduce the chances of the communication of information from student to student. However, in our pilot work we found that the number of transpositional cryptograms of suitable difficulty level for the experiment were severely limited. We therefore wrote five different forms of each test. All testing was done in a given school in one day. No subject was ever tested twice. Each class had a different sample of students. These precautions, plus using three different schools

gives considerable confidence in the assumption that we were measuring fairly the student's ability to solve the cryptograms.

Another embellishment, which was introduced to increase the precision of the experiment, was the use of each subject on either but not both the problem solving test or the deriving rule test. In a pilot study we found that subjects who had taken both of these tests had found the second test to be easier probably as a result of their experience with the first test. Although we would have to double the number of subjects to provide a respectable n on each dependent variable, the added effort on our part was necessary to avoid the practice effect. Therefore, no subject received both examinations. This had an added advantage. It enabled us to sample other kinds of transfer with the time left over from the deletion of one of the previous tests.

The above mentioned problems and several other minor problems were described in the Quarterly Progress Report for the March 2 to September 1 period. However, all these problems were minor. Most of the problems were overcome by the series of four pilot studies. As a result of these interesting pilot studies, much more research and experimentation was conducted than was required in the original contract. As each pilot study was completed, the issues became clearer in some ways and more complex in others. The end result was the elaborate design of Experiment II as reported above.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Several years of study on transfer of training preceeded the series of studies summarized below. From the previous work, which used college students and elementary school students, several relationships between cueing and transfer seemed tenable. First, it had been repeatedly found that highly directed procedures often produced the most initial learning of a few specifics. The greatest transfer to new examples of the previously learned concepts was often produced by a cue which mentioned the rule or the concept but not the specific answers to problems. Also it was shown that transfer to new concepts, a remote type of transfer, was fairly impervious to any of the previously used cues, either in the author's work or in the work of others.

In Chapters I through VII of the report are the hypotheses and empirical data, including their analyses, which were stimulated by the earlier work. Of specific interest in four pilot experiments and two final experiments were the following questions. How would the earlier findings fare with secondary school populations? Would a new independent variable, variety of classes of stimuli, produce an effect on remote transfer when all of the earlier attempts had failed? How would mediation theory, coupled with the earlier empirical results, enable us to predict the primary and interactional effects of rules, answers, and feedback when the dependent variables were learning, retention, and transfer? How would the dependent variables of affectivity and motivation be affected by the cues?

Four hypotheses were developed and were tested. These hypotheses were derived from the previous work and from an interpretation of mediation theory.

Hypothesis I. When transfer to deciphering new examples of previously learned rules is a criterion, a procedure which specifies relevant rules, compared with a comparable procedure which does not specify the relevant rules, increases performance.

Hypothesis II. Giving rules and unanswered examples, compared with a procedure which does not give rules but gives answered examples, increases performance on a transfer

test which involves applying previously learned rules to the deciphering of new examples of the same rules.

Hypothesis III. Feedback, which specifies the rule and the correct answers to problems that represent the rule, enhances the performance on tests of retention and transfer to new examples of the learned rules to a greater extent when the rules as prompts are not given to learners than when rules as prompts are given to learners.

Hypothesis IV. Feedback, which includes the correct answers to the problems, enhances performance on tests of learning to a greater extent when answers as prompts are not given to learners than when answers as prompts are given to learners.

The first pilot study used college students. All of the other pilot studies and both experiments used public secondary school subjects. The materials were transpositional and substitutional cryptograms. These problems, along with the commentary, cues, and instruction were presented in simple, individual teaching machines. The independent variables were 1) Rules, 2) Answers, and 3) Feedback.

In the first pilot study, the primary purpose was to find if a variety of classes of problems would produce transfer, especially remote transfer. The results of this study were published in Psychological Reports (1964b). Either rules or a variety of classes facilitated transfer to new examples of transpositional cryptograms.

The second, third, and fourth pilot studies were designed to tell if the earlier findings with college students and elementary students would hold true with secondary school students. Pilot Study II presented cryptograms of several different difficulty levels. The object was to find how easy or difficult problems should be for these secondary school subjects. The instructional programs, including the problems, proved to be quite difficult for the secondary school students. Unlike the college students, these students were not as challenged by a difficult problem. They were more dependent on small steps, frequent, and immediate reinforcement. Without this support some were not motivated to continue.

Pilot Studies III and IV enabled us to prepare materials of appropriate difficulty level, a major undertaking, and to prepare tests that would discriminate among the treatments. These two pilot studies also gave us "dry runs" with the rule and answer variables. In Pilot Study III

we found that initial learning was best produced by the answer variable. The rule variable was not effective on initial learning or on transfer to new examples of previously studied rules. Since this lack of transfer was so different from any of our earlier findings, the instructional materials were drastically revised.

In Pilot Study IV these revised materials behaved as we predicted they would. A combination of answers and rules produced the greatest initial learning, but near transfer was greatest for the group given rules but not answers. The differences were statistically significant and the materials were considered ready for the experiments proper.

In Experiment I, there were 300 secondary school students, 150 eleventh graders and 150 twelfth graders. Two independent variables, rules and answers, were investigated. Feedback was not studied. All possible combinations of these two independent variables gave four treatment groups. One control group, which was given only the tests, was added. The subjects were assigned individually at random to the five groups. In addition, each group was split on the basis of whether a problem solving test or a derivation of rules test was given. That is, no subject took both tests since practice on one test might have confounded results on the second test.

After the instruction was completed, half of all the subjects received the problem solving test. This contained items that were designed to measure initial learning, transfer to new examples, and transfer to new rules. A separate measure of affectivity was also obtained.

In the problem solving test, the rule variable produced a dependable effect on transfer to new examples. The rules helped transfer. This supported Hypothesis I and also the results obtained in previous research. However, the rule variable did not produce statistically significant effects on the transfer to substitutional rules subtest.

The answer variable produced no statistically significant effect on either of the transfer tests, but did produce an effect on the affectivity ratings. The students who were not given answers to the problems rated the lesson more positively than did those students who were given answers to the problem. Apparently, one reason the rule variable may be effective is that, when answers are not given, the students feel more

positive about working the problems than they do when answers are given along with the rules. Hypothesis II was also supported because the rule given, answer not given group performed better than the group given the answers but not the rules on the transfer to new examples test.

Another important dependent variable is ability of the students to derive rules when given answered examples. Half of all the subjects in the treatments were given a derivation of rules test rather than a test which had them solve problems of deciphering cryptograms. On this dependent variable, neither the answer nor the rule variable produced any effect. However, when variations in quantitative thinking scores were controlled statistically by analysis of covariance, the rule variable did produce a dependable effect on near transfer. The groups that were given the rules scored higher than the groups that were not given rules. On the remote transfer test, transfer to substitutional rules, the rule variable did not produce a dependable effect. The answer variable did produce a dependable effect, in favor of the answer given group. This latter finding is striking in that it has never been found by the author before. Because of lack of experience with remote transfer as a dependent variable, no hypothesis about this dependent variable was tested. This dependent variable was explored further in Experiment II, which is described below.

The results of Experiment I agreed quite closely with the findings of earlier work. It seems that the rule variable, as predicated by mediation theory, is an important one for producing transfer to new examples of the rule. Also, it seems that with properly designed materials, this effect of the rule variable applies to secondary school populations or at least to some secondary school students. The affectivity results and the remote transfer results must be considered tentative, since there is little previous data to support them. The two hypotheses which were tested in Experiment I, Hypothesis I and Hypothesis II, were both supported.

Because the results of Experiment I were so closely in agreement with Hypothesis I and Hypothesis II, and because that experiment raised

some important questions about remote transfer and the variables which might influence it, it was decided that another experiment would be necessary. Experiment II was considerably more elaborate than Experiment I. Thanks to the U.S. Office of Education for additional time and money, and to Mr. Joseph Murnin for his help, the second experiment was completed.

In Experiment II, a third independent variable, feedback, was added. All possible combinations of the three independent variables gave a total of eight treatment groups. In addition one control group was given only the learning and transfer test. Again half of the subjects were given a derivation of rules test, while half of the subjects were given a problem solving test which involved deciphering cryptograms. Because of a limited supply of secondary school students, it was not possible to give feedback to those subjects who took the derivation of rules test. Therefore, the effects of feedback were studied only in relation to the deciphering of cryptograms.

There were 383 secondary school students in Experiment II. Almost all of these were eleventh or twelfth grade students. All subjects were individually assigned at random to the experimental conditions. As in Experiment I, individual teaching machines were used. This allowed all treatments to exist simultaneously in the same classroom.

After the instructional sequences were completed, the tests were given. An immediate test sampled initial learning, transfer to new examples, transfer to new transpositional rules, transfer to substitutional rules, affectivity, and a record of the time taken on this test. A delayed test was given one week later and measured the same dependent variables mentioned above plus motivation to practice cryptography after the learning was completed. In addition to the immediate and delayed tests, several measures were obtained during the learning lesson: affectivity, motivation, time, and error rate.

One entire chapter of the Final Report, Chapter VII, is devoted to a discussion of the results of Experiment II. Over 60 pages of commentary, graphs, and figures were needed to describe thoroughly the primary and interaction effects of three independent variables upon

the array of dependent variables used in this elaborate design. The most important of these effects are mentioned below. For a more detailed discussion of the analyses of variance and covariance and for graphs of the significant double and triple interactions please see Chapter VII.

Among the half of the experimental population who were given the problem solving test rather than the derivation of rules test, the following results appeared. The rule variable produced a significant effect on learning and on transfer to new examples. This was true on both the immediate and the delayed tests. The groups given the rules learned and transferred more than did those groups who were not given the rules. Hypothesis I was thus supported. Hypothesis II was also supported, but only for those groups who were not given feedback. The group that was given the rule but not the answer was dependably better than the group not given the rule but given the answer so long as feedback was not given. Among the feedback given groups, no dependable effect was found. All groups seemed to have done relatively well when they were given the rules through feedback. This result does not detract from Hypothesis II because the feedback specified both rules and answers. Therefore Hypothesis II was not tested when feedback was supplied.

The third hypothesis, which stated that feedback enhances learning, retention, and transfer when rules as prompts are not given more than when rules as prompts are given, was not supported. Hypothesis IV was supported by a dependable answer by feedback interaction ($p < .01$). However, this dependable interaction showed up only on the learning test. Feedback, which included the correct answer, enhanced learning greater when answers were not given as prompts than when answers were given as prompts. This finding supports the general notion derived from mediation theory that for maximum initial learning both answers and rules should be specified. If either one is not specified as a prompt, then specifying it through feedback tends to increase initial learning. The worst condition, in terms of initial learning, was to give no answers in the form of prompts or feedback. The answer variable also produced a primary effect on the learning task, as did the feedback

variable. However these primary effects must be interpreted in light of the answers x feedback interaction which was discussed above. In either case, specifying answers or feedback enhanced learning compared with not specifying either of these respectively.

On the delayed test of deciphering cryptograms, transfer to new examples was affected in the following way. There were primary effects due to rules, and to answers, and an interactional effect due to rules x answers, and another one due to rules x answers x feedback. The two primary effects as well as the double interaction must be interpreted in light of the triple interaction. When feedback was given there was little difference between giving or not giving answers. However, when feedback was not given, giving rules was dependably better than not giving rules.

When affectivity was the dependent variable, the rule variable produced a primary effect. Groups that were given the rules rated the lesson as more enjoyable than those that were required to produce the rule for themselves. The answer variable did not produce a reliable effect. When motivation was the dependent variable, there was a rule by feedback interaction. Feedback lowered the rating when rules were not given. When feedback was not given, rules had little advantage over the condition where rules were not given. It may be distasteful for learners to be given the rule through feedback after they have failed at deriving the rule on their own. This suggests that the secondary school students did not enjoy learning that they had made mistakes.

When the students responded to the question about whether or not they had practiced solving cryptograms after the learning session, there was an answer x rule interaction which was reliable. The interaction suggested that an intermediate amount of direction aroused interest and caused the learners to practice outside of class more than those learners who were given either maximum or minimum amounts of information.

With time as a dependent variable, it was obvious that those who were given a minimum amount of information took the longest time to finish. Both on the learning lesson and the immediate test, the answer variable produced a reliable effect. Those people given answers took less

time to perform than those people who weren't given answers. The rule variable also produced a reliable effect. Those people given rules took less time to perform than those not given rules. These latter two findings are especially encouraging, because the cues given in this study not only increased mean performance but also decreased the amount of time it took both to learn and to perform on the test.

Because none of the treatments produced an effect on the transfer to new rules or the transfer to substitutional rules subtests, an analysis of covariance was performed. The different levels of learning were controlled statistically. The covariable was the learning score. It should be remembered that when the experimental treatments affect the covariable, part of the experimental treatment effect is removed along with the error component. The results of the covariance technique generally supported the three way analysis of variance summarized above. However, the rule and answer variables produced primary effects on the transfer to new rules subtest, but only on the immediate test. There is a weak suggestion here that rules and answers may also affect remote transfer as well as near transfer. The direction was the same as that found above; namely, those groups given the rules or answers respectively performed better on this transfer test than those groups not given the rules or answers.

Among those subjects who were given the derivation-of-rules test, rather than the deciphering cryptograms test, the following results were found. (Please remember that feedback was not an independent variable which was studied in this half of Experiment II. Neither were there any hypotheses about the effects produced on this dependent variable. There was not a previous experiment which would enable us to predict effects upon this dependent variable.) The interesting finding on the derivation-of-rules test, both the immediate and delayed batteries, was that the rule variable produced a primary effect on the learning and on the transfer to new examples subtests. On the immediate test, the rule variable also produced a primary effect on the transfer to new transpositional rules and transfer to substitutional rules subtests. However, by analysis of covariance these latter two effects were removed. The covariable was initial learning.

In agreement with the results on the problem solving test, the groups given the rules learned and transferred to new examples of these same rules more than did those groups not given the rules. Neither the answer variable nor none of the interactions was significant on the derivation-of-rules test. Apparently the rule variable is again important. It also seems that transfer to new rules or transfer to substitutional rules is affected by the rule variable because the rule variable leads to greater initial learning and transfer to new transpositional examples.

When affectivity was a dependent variable, rules produced a significant effect. Those students given the rules gave a more positive affectivity score than did the groups not given the rules. These results also support those on the problem solving tests described above.

When the dependent variables were motivation or practice at deriving rules after the experiment was completed, there was no reliable effect due to any independent variable. The derivation-of-rules test either was not as sensitive to the differences produced by the independent variables or the performance sampled by the derivation-of-rules test was affected differently from the problem solving performance by these independent variables. It is too early to make a conclusive statement.

As with the problem-solving results, both the rule and answer variables produced a statistically significant effect upon time. Giving the rules or answers reduces the time to learn and to perform on the test.

The lesson error rate was also reduced by giving answers. Further, the lesson error rate was reduced by giving rules. In close agreement with the earlier results and the results summarized above for the problem-solving test, initial learning is increased by supplying information about rules, answers, or both.

The results of Experiment II agreed closely with those of Experiment I and elaborated upon them. The four hypotheses, which are mentioned above fared well within Experiment I, where two of them were tested, and in Experiment II, where all four of them were tested. There is little doubt that behavior which involves deciphering transpositional cryptograms is affected by the rule or answer information given during learning. Apparently this is true for college students, high school students,

and with similar materials, for elementary school students. It also seems clear that transfer to new examples of previously learned rules (near transfer) is definitely influenced by the rule variable.

As a result of Experiment II, we have some information about some of the processes which may be in operation here. When the student is given information which helps him to get correct answers, not only does his performance at deciphering problems increase, but also his affectivity toward the subject matter increases. It is not known whether it is this positive affectivity which is mediating his cognitive behavior or vice versa. It may be that he comes to like the subject matter as a result of his improved performance or it may be that because he likes the subject matter, his performance is improved. In either case it apparently is the rule variable which initiates the effects measured on affectivity or on the learning and transfer tests.

It is equally apparent that, with the exception of the variety variable, none of the procedures used in this series of experiments was effective at producing remote transfer, either to new transpositional rules or to new substitutional rules. Remote transfer is an extremely important dependent variable, and from our results with Pilot Study I, it would seem that variety is an important independent variable which should be explored further. To produce a sizeable effect upon remote transfer, further independent variables should be studied. Probably a greater amount of time will have to be devoted to the learning exercise. There is also need to pay further attention to individual differences in relation to the treatments.

In Experiment II, ability level was introduced as a factor in a separate analysis of variance. However, the results were complicated and are not described in the summary. See Chapter 7 for an analysis of individual differences in ability and their relation to the effectiveness of rules, answers, and feedback.

Mediation theory and the empirical results found earlier by the author appeared to be strongly supported by the pilot studies and the two experiments performed in the series. It is also apparent that future studies can profit from using a variety of dependent variables, such as time, affectivity,

remote transfer, transfer to new transpositional rules, etc., because the results obtained on one dependent variable are not sufficient to explicate the intellectual and cognitive processes in operation in these situations. Mediation theory and the hypotheses which were derived from it appear to have received additional support in this series. The next logical step would be to use the independent variables of this study, to supplement them with further independent variables, and to design treatments to produce an effect upon remote transfer.

REFERENCES

- Ammons, R.B. Effects of knowledge of performance: A survey and tentative theoretical formulation. J. Gen. Psychol., 1956, 54, 279-299.
- Anderson, N.S., & Leonard, J.A. Recognition, naming, and reconstruction of visual figures as function of contour redundancy. J. exp. Psychol., 1958, 56, 262-270.
- Angell, D., & Lumsdaine, A.A. Prompted and unprompted trials versus prompted trials only in paired-associate learning. In A. Lumsdaine (Ed.), Student response in programmed instruction., Washington, D.C. : National Academy of Sciences-National Research Council, 1961 (a).
- Angell, D., & Lumsdaine, A.A. The effects of prompting trials and partial-correction procedures on learning by anticipation. San Mateo, Calif. : American Institute for Research, September, 1961(b). Report No. AFOSR-TN-61-1343.
- Ausubel, D.P. The psychology of meaningful verbal learning. New York: Grune & Stratton, 1963.
- Bartlett, M.S. A note on the analysis of covariance. Jour. Agr. Sci., 1936, 26, 448.
- Birge, J.S. The role of verbal responses in transfer. Ph.D. dissertation, Yale University, 1941.
- Brackbill, Y., Wagner, J.E., & Wilson, D. Feedback delay and the teaching machine. Psychology in the Schools., 1964, 1, 148-156.
- Briggs, L.J. Prompting and confirmation conditions for three learning tasks employing the Subject-Matter Trainer. In A. Lumsdaine (Ed.), Student response in programmed instruction., Washington, D.C. : National Academy of Sciences-National Research Council, 1961.
- Cantor, G.N. Effects of three types of pretraining on discrimination learning in preschool children. J. exp. Psychol., 1955, 49, 332-42.
- Cochran, W.G., & Cox, G.M. Experimental designs. New York: Wiley, 1950.
- Cofer, C.N., & Foley, J.P., Jr. Mediated generalization and the interpretation of verbal behavior: I. Prolegomena. Psychol. Rev., 1942, 49, 513-540.
- Cook, J.O. Supplementary report: Processes underlying learning a single paired-associate item. J. exp. Psychol., 1958, 56, 455.

- Cook, J.O. From audience participation to paired associated learning. In A. Lumsdaine (Ed.) Student response in programmed instruction. Washington, D.C. : National Academy of Sciences-National Research Council, 1961.
- Cook, J.O., & Kendler, T.S. A theoretical model to explain some paired-associate learning data. In G. Finch and F. Cameron (Eds.) Symposium on Air Force human engineering, personnel and training research. Washington, D.C. : National Academy of Sciences-National Research Council, 1956.
- Cook, J.O., & Spitzer, M.E. Supplementary report: Prompting versus confirmation in paired-associate learning. J. exp. Psychol., 1960, 59, 275-276.
- Craig, R.C. Directed versus independent discovery of established relations. J. educ. Psychol., 1956, 47, 223-234.
- Dietze, D. Facilitating effect of words on discrimination and generalization. J. exp. Psychol., 1955, 50, 255-260.
- Dixon, W.J. Biomedical Computer Program. Los Angeles, U.C.L.A., Health Sciences Computing Facility, 1964.
- Dollard, J., & Miller, N.E. Personality and Psychotherapy. New York: McGraw-Hall, 1950.
- Edwards, A.L. Experimental design in psychological research. New York: Rinehart, 1960.
- Elwell, J.L. & Grindley, G.C. The effect of knowledge of results on learning and performance. A coordinated movement of the two hands. Brit. J. Psychol., 1938-9, 39, 39-54.
- Evans, J.L., Glaser, R., Homme, L.E. An investigation of "teaching machine" variables using learning programs in symbolic logic. J. teacher Education, 1962, 55, 433-452.
- Ewert, P.H. and Lambert, J.F. Part II, The effect of verbal instructions upon the formation of a concept. J. gen. Psychol., 1932, 6, 400-12.
- Feldhusen, J.F., & Birt, A. A study of nine methods of presentation of programmed learning material. J. educ. Res., 1962, 55, 459-66.
- Fitts, P.N., Weinstein, N., Rappaport, M., Anderson, N., & Leonard, J.A. Stimulus correlates of visual pattern recognition: A probability approach. J. exp. Psychol., 1956, 51, 1-11.
- Forgus, R.H., & Schwartz, R.J. Efficient retention and transfer as affected by learning method. J. Psychol., 1957, 43, 135-139.
- Goss, A.E., Verbal mediating responses and concept formation. Psychol. Rev., 1961, 68, 248-274.

- Haslerud, G.N., & Meyers, Shirley. The transfer value of given and individually derived principles. J. educ. Psychol., 1958, 49, 293-298.
- Hirsch, R.S. The effects of knowledge of test results on learning of meaningful material. (Pennsylvania State University Instructional Film Research Program), Port Washington, New York: U.S. Naval Training Devices Center, Office of Naval Research, 1950. Technical Report. SDC 269-7-19.
- Holland, J.G. Program design and use. Paper read at American Psychology Association, Chicago, September, 1960.
- Hovland, C.I., Lumsdaine, A.A., & Sheffield, F.D. Experiments on mass communication. Princeton: Princeton University Press, 1949.
- Irwin, F.S., Kaufman, K., Prior, G., & Weaver, H.B. On 'learning without awareness of what is being learned.' J. exp. Psychol., 1934, 17, 823-827.
- Judd, C.H. Practice without knowledge of results. Psychol. Rev. Monog. Suppl., 1905-6, 7, 185-198.
- Kemphorne, O. The design and analysis of experiments. New York: Wiley, 1952.
- Kendler, H.H., & Kendler, T.S. Effect of verbalization on reversal shifts in children. Science, 1961, 134, 1619-20.
- Kendler, H.H., & Kendler, T.S. Inferential behavior in preschool children. J. exp. Psychol., 1956, 51, 311-314.
- Kendler, H.H., & Kendler, T.S. Vertical and horizontal processes in problem solving. Psychol. Rev., 1962, 69, 1-16.
- Kendler, T.S., & Kendler, H.H. Reversal and non-reversal shifts in kindergarten children. J. exp. Psychol., 1959, 58, 56-60.
- Kendler, T.S., Kendler, H.H., & Wells, D. Reversal and non-reversal shifts in nursery school children. J. comp. physiol. Psychol., 1960, 53, 83-88.
- Kersh, B.Y. Directed discovery vs. programed instruction: A test of a theoretical position involving educational technology. Final Report, NDEA P-907, 1964, U.S. Office of Education, Department of Health, Education, and Welfare, Washington, D.C.
- Kersh, B.Y. The motivating effect of learning by directed discovery. J. educ. Psychol., 1962, 53, 63-71.

- Kittell, J.E. An experimental study of the effect of external direction during learning on transfer and retention of principles. J. educ. Psychol., 1957, 48, 391-405.
- Krumboltz, J.D. & Weisman, R.G. The effect of intermittent confirmation in programmed instruction. Paper presented to the American Psychological Association, St. Louis, September, 1962.
- Lambert, P. Schedules of reinforcement: effects on programmed learning. Paper presented to the American Psychological Association, St. Louis, September 1962.
- Li, J.C. R. Introduction to statistical inference. Ann Arbor: Edwards Brothers, 1957.
- Lindquist, E.F. Design and analysis of experiments in psychology and education. Boston: Houghton Mifflin, 1953.
- Little, J.K. Results of use of machines for testing and for drill upon learning in educational psychology. J. exp. Educ., 1934, 3, 45-49.
- Lubin, A. The interpretation of significant interaction. Educ. Psychol. Measurement., 1961, 21, 807-817.
- Maccoby, N., Michael, D.N., & Levine, S. Further studies of student participation procedures in film instruction: review and preview covdrt practice, and motivational interactions. In A. Lumsdaine (Ed.), Student response in programmed instruction. Washington, D.C. : National Academy of Sciences-National Research Council, 1961.
- Maier, N.R. F. Reasoning in humans: I. On direction. J. Comp. Psychol., 1930, 10, 115-43.
- Michael, D.N., & Maccoby, N. Factors influencing verbal learning films under varying conditions of audience participation. J. exp. Psychol., 1953, 46, 411-418.
- Miller, G.A. Language and Communication. New York: McGraw-Hill Book Co. Inc., 1951.
- Moore, J.W., & Smith, W.I. Knowledge of results in self-teaching spelling. Psychol. Rep., 1961, 9, 717-727.
- Morgan, J.J. Effect of non-rational factors on inductive reasoning. J. exp. Psychol., 1944, 34, 159-68.
- Murdock, B.B. Jr. Response-factors in learning and transfer. Amer. J. Psychol., 1960, 73, 355-69.
- Norcross, K.J., & Spiker, C.C. The effects of type of stimulus pretraining on discrimination performance in preschool children. Child Developm. 1957, 28, 79-84.

- C' Brien, J.A. Silent reading. New York: The Macmillan Company, 1921.
- Osgood, C.E. Method and Theory in Experimental psychology. New York: Oxford University Press, 1953, 668-72 & 695-714.
- Ostle, B. Statistics in research. Ames: Iowa State University Press, 1963.
- Peterson, J.C. A new device for teaching, testing and research in learning. Transactions of the Kansas Academy of Science, 1930, 33, 41-47.
- Peterson, J.C. The value of guidance in reading for information. Transactions of the Kansas Academy of Science, 1931, 34, 291-296.
- Pressey, S.L. Development and appraisal of devices providing immediate automatic scoring of objective tests and concomitant self-instruction. J. Psychol., 1950, 29, 417-447.
- Pressey, S.L. A machine for automatic teaching of drill material. School and Society, 1927, 25, 549-552.
- Pressey, S.L. A simple apparatus which gives tests and scores - and teaches. School and Society, 1926, 23, 373-376.
- Pressey, S.L. A third and fourth contribution toward the coming industrial revolution in education. School and Society, 1932, 36, 668-672.
- Rubinstein, H., & Aborn, M. Psycholinguistics. Ann. rev. Psychol., 1960, 11, 231-222.
- Shipstone, E.I. Some variables affecting pattern conception. Psycho. Monogr. 1960, 74, (17, Whole No. 504).
- Sims, V. M. The relative influence of two types of motivation on improvement. J. educ. Psychol., 1928, 19, 480-484.
- Skinner, B.F. The science of learning and the art of teaching. Harvard Educational Review, 1954, 24, 86-97.
- Staats, A.W. Verbal habit-families, concepts and operant conditioning of word classes. Psychol. Rev., 1961, 68, 190-204.
- Stolurow, L. M. Teaching by machine. Cooperative Res. Monogr. No. 6. (OE-34010) Washington, D.C. : U.S. Government Printing Office, 1961.
- Swets, J.A., Millman, Susan H., Fletcher, W.E., & Green, D.M. Learning to identify nonverbal sounds: An application of a computer as a teaching machine. J. Acoust. Soc. Am., 1962, 34, 928-235.
- Thorndike, E.L., & Lorge, I. The teacher's word book of 30,000 words. New York: Bureau of Publications, Teachers College, Columbia University, 1944.

- Trowbridge, M.H., & Cason, H. An experimental study of Thorndike's theory of learning. J. Gen. Psychol., 1932, 7, 245-260.
- Winer, B.J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.
- Wittrock, M.C. Transfer through verbal cueing in Concept Identification. Final Report, Coop. Res. Program Project No. 1684, Washington, D.C., U.S. Office of Education; Department of Health, Education, and Welfare, 1964.
- Wittrock, M.C. Verbal stimuli in concept formation: Learning by discovery. J. educ. Psychol., 1963, 54, 183-190.
- Wittrock, M.C., Keislar, E.R., & Stern, Carolyn. Verbal Cues in Concept Identification. J. educ. Psychol., 1964, 55, 195-200.
- Wittrock, M.C., & Twelker, P.A. Prompting and feedback in the learning, retention and transfer of concepts. Brit. J. educ. Psychol., 1964, 34, 10-18. (a)
- Wittrock, M.C., & Twelker, P.A. Verbal cues and variety of classes in transfer of training. Psychol. Rep., 1964, 14, 827-830. (b)
- Wofle, D. Training. In S.S. Stevens (Ed.), Handbook of experimental psychology. New York: Wiley, 1951.

APPENDIX A

Adjusted Treatment Means and Scores on the Immediate Test of Transfer (Covariance Analysis Test of Learning)

Treatment Group	Transfer to New Language (3 Items)	Transfer to New Transpositional Rules (3 Items)	Transfer to New Substitutional Rules (3 Items)
A n = 10 F = 2.1	2.1	2.4	1.1
B n = 10 F = 2.1	2.1	1.7	1.7
C n = 10 F = 2.1	2.1	2.1	1.1
D n = 10 F = 2.1	2.1	2.1	1.1
E n = 10 F = 2.1	2.1	2.1	1.1
F n = 10 F = 2.1	2.1	2.1	1.1
G n = 10 F = 2.1	2.1	2.1	1.1
H n = 10 F = 2.1	2.1	2.1	1.1
I n = 10 F = 2.1	2.1	2.1	1.1
J n = 10 F = 2.1	2.1	2.1	1.1

RESULTS OF THE SUPPLEMENTARY
ANALYSIS OF VARIANCE OF THE PROBLEM-SOLVING
TEST SCORES (LEARNING SCORE AS THE COVARIABLE)

Note: The regression coefficients calculated from the experimental error sum of squares and provided for each test were, respectively, .37, .60, and .38.

Table A1

Adjusted Treatment Group Means for Scores on the Immediate Test of
Transfer (Covariable: Immediate Test of Learning)

Treatment Group	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
A R F g g ng n=22	2.07	2.02	1.10
A R F g ng ng n=28	1.36	1.83	.70
A R F ng g ng n=30	2.35	2.14	.98
A R F ng ng ng n=24	1.74	2.21	1.44
A R F g g g n=30	2.09	1.86	.81
A R F g ng g n=29	1.75	1.76	1.17
A R F ng g g n=29	2.14	2.43	.81
A R F ng ng g n=28	1.75	2.03	.93

Note: the regression coefficients calculated from the experimental error sum of squares and produces for each test were, respectively, .97, .69, and .50.

Table A 2

Summary of the Three-way Analysis of Covariance for Scores on the Immediate Test of Transfer
(Covariable: Immediate Test of Learning)

Source	Transfer to New Examples			Transfer to New Transpositional Rules			Transfer to Substitutional Rules		
	df	MS	F	MS	F		MS	F	
Answer (A)	1	1.48	1.26	5.84	6.03		.42	.30	
Rule (B)	1	14.34	12.24***	1.32	1.37		.90	.65	
Feedback	1	1.20	.10	.08	.08		.86	.62	
A x R	1	.00	.00	.01	.01		1.24	.89	
A x F	1	1.36	1.16	.36	.37		2.51	1.80	
R x F	1	1.73	.92	.55	.57		.56	.40	
A x R x F	1	.10	.09	1.13	1.17		4.22	3.03	
Error	211	1.17	.97				1.39		

*p < .05

***p < .001

Table A 3

Adjusted Treatment Group Means for Scores on the Delayed Tests of Learning and Transfer (Covariable: Immediate Test of Learning)

Treatment Group	Learning (3 items)	Transfer to New Examples (3 items)	Transfer to New Transpositional Rules (3 items)	Transfer to Substitutional Rules (3 items)
$A_{g g} R_{g g} F_{n g}$ $n=26$	2.96	2.16	2.31	1.52
$A_{g n g} R_{n g} F_{n g}$ $n=21$	2.67	1.85	2.52	1.66
$A_{n g} R_{g g} F_{g g}$ $n=23$	2.90	2.21	2.45	1.16
$A_{n g} R_{n g} F_{g g}$ $n=26$	2.85	1.96	2.27	1.42
$A_{g g} R_{g g} F_{n g}$ $n=20$	2.64	1.63	2.19	1.51
$A_{g n g} R_{n g} F_{n g}$ $n=25$	2.87	1.49	2.46	1.17
$A_{n g} R_{g g} F_{n g}$ $n=25$	2.89	2.55	2.40	1.69
$A_{n g} R_{n g} F_{n g}$ $n=22$	2.67	2.00	2.56	1.86

Note: The regression coefficients calculated from the experimental error sum of squares and products for each test were, respectively, .34, .99, .66, and .84.

Table A 4

Summary of the Three-way Analysis of Covariance for Scores on the Delayed Test of Learning and Transfer
(Covariable: Immediate Test of Learning)

Source	Learning			Transfer to New Examples		Transfer to New Transpositional Rules		Transfer to Substitutional Rules	
	df	MS	F	MS	F	MS	F	MS	F
Answer (A)	1	.20	1.11	16.37	14.85***	.07	.10	1.67	1.12
Rule (R)	1	.30	1.66	7.96	7.22**	.29	.40	.21	.14
Feedbacks (F)	1	.05	.29	1.05	.95	.00	.00	2.20	1.50
A x R	1	.13	.72	3.71	3.37	.15	.21	.09	.07
A x F	1	.01	.03	7.62	6.92**	.16	.23	5.16	3.51
B x C	1	.15	.80	2.95	2.68	.64	.88	2.16	1.47
A x R x F	1	1.23	6.73*	4.94	4.48	.37	.51	.03	.02
Error	179	.18		1.10		.72		1.47	

* $p < .05$ ** $p < .01$ *** $p < .001$

Table A 5

Adjusted Treatment Group Means for Affectivity and Motivational Ratings
for the Learning Program (Covariable: Immediate Test of Learning)

Treatment Group	Affectivity Rating	Motivational Rating
$A_{g g g} R_{g g g} F_{g g g}$ $n=30$	5.56	5.79
$A_{g n g} R_{n g n} F_{g n g}$ $n=29$	4.71	4.41
$A_{n g n} R_{g n g} F_{g n g}$ $n=29$	5.54	5.77
$A_{n g n} R_{n g n} F_{g n g}$ $n=28$	5.50	4.78
$A_{g g n} R_{g g n} F_{n g n}$ $n=22$	5.22	5.30
$A_{g n g} R_{n g n} F_{n g n}$ $n=28$	4.15	5.10
$A_{n g n} R_{g n g} F_{n g n}$ $n=20$	5.73	5.36
$A_{n g n} R_{n g n} F_{n g n}$ $n=24$	5.09	5.30

Note: the regression coefficients calculated from the experimental error sum of squares and products for each rating were, respectively, .85 and .69.

Table A 6

Summary of the Three-way Analysis of Covariance for the Affectivity and Motivational Ratings for the Learning Program (Covariable: Immediate Test of Learning)

Source	df	Affectivity Rating		Motivational Rating	
		<u>M.S</u>	<u>F</u>	<u>M.S</u>	<u>F</u>
Answer (A)	1	15.71	6.38*	1.13	.37
Rule (R)	1	22.67	9.21**	23.55	7.72
Feedback (F)	1	3.97	1.61	.37	.12
A x R	1	5.04	2.05	.84	.27
A x F	1	1.54	.62	.02	.01
R x F	1	2.13	.86	15.42	5.05*
A x R x F	1	.39	.16	.17	.06
Error	211	2.46		3.05	

* $p < .05$

** $p < .01$

Table A 7

Adjusted Treatment Group Means for Affectivity Ratings on the Immediate and Delayed Tests of **Learning and Transfer**
(Covariable: Immediate Test of Learning)

Treatment Group	Immediate Test	Delayed Test
$A_{gR} F_g$	4.55	4.49
$A_{gRng} F_g$	4.09	4.38
$A_{ngR} F_g$	4.41	4.36
$A_{ngRng} F_g$	3.81	4.52
$A_{gR} F_{ng}$	4.02	4.32
$A_{gRng} F_{ng}$	3.59	4.43
$A_{ngR} F_{ng}$	4.22	4.88
$A_{ngRng} F_{ng}$	4.89	4.84

Note: The regression coefficients calculated from the experimental error sum of squares and products for each rating were, respectively, .68 and 1.11.

Table A 8

Summary of the Three-way Analysis of Covariance for the Affectivity Ratings on the Immediate and Delayed Test of Learning and Transfer
(Covariable: Immediate Test of Learning)

Immediate Test				Delayed Test			
Source	df	MS	F	df	MS	F	
Answer (A)	1	5.84	6.02*	1	3.48	1.13	
Rule (B)	1	1.32	1.37	1	2.42	.74	
Feedback (F)	1	.08	.08	1	.04	.01	
A x R	1	.01	.01	1	2.94	.90	
A x F	1	.36	.37	1	12.05	3.69	
A x R x F	1	1.13	1.17	1	5.46	1.67	
Error	211	.9685		179	3.26		

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* p< .05

RESULTS OF THE SUPPLEMENTARY ANALYSIS
OF VARIANCE OF THE DERIVATION OF RULES
TEST SCORES (LEARNING SCORE AS THE COVARIABLE)

Table B1

Adjusted Treatment Group Means for Scores on the Immediate Tests of Transfer. Covariable Immediate Test of Learning

Treatment Group	Transfer to New Examples	Transfer to New Transpositional Rules	Transfer to Substitutional Rules
A_{gR}	1.47	1.96	2.01
$A_{gR_{ng}}$	1.16	1.95	1.88
$A_{ngR_{g}}$	1.67	2.05	2.02
$A_{ngR_{ng}}$	1.12	1.88	1.89

Table B2

Adjusted Treatment Group Means for Scores on the Delayed Tests
Covariable: Immediate Test of Learning

Treatment Group	Learning	Transfer to New Examples	Transfer to New Transpositional Rules	Transfer to Substitutional Rules
A_{gR}	1.84	1.80	2.16	2.63
$A_{gR_{ng}}$	1.32	1.41	2.25	2.13
$A_{ngR_{g}}$	1.95	1.94	2.39	2.30
$A_{ngR_{ng}}$	1.72	1.63	2.51	2.52

Table B3

Summary of the Two-way Analysis of Covariance for Scores on the Immediate Tests of Transfer
(Covariate: Immediate Test of Learning)

Source	df	Transfer to New Examples		Transfer to New Transpositional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F
Answer (A)	1	.16	.24*	---	---	---	---
Rule (R)	1	3.65	5.40*	.15	.20	.33	.29
A x R	1	.38	.57	.16	.22	---	---
Error	95	.68		.71		1.14	

* $p < .05$

Table B4

Summary of the Two-way Analysis of Covariance for Scores on the Delayed Tests of Learning and Transfer

Source	df	Learning		Transfer to New Examples		Transfer to New Transpositional Rules		Transfer to Substitutional Rules	
		MS	F	MS	F	MS	F	MS	F
Answer (A)	1	1.36	1.47	.73	.76	1.19	1.81	.03	.03
Rule (R)	1	2.40	2.59	1.98	2.07	.20	.30	.34	.35
A x R	1	.42	.45	.03	.03	---	---	2.71	2.81
Error	79	.93		.96		.66		.96	

Table B5

Adjusted Treatment Group Means for the Affectivity and Motivational Ratings for the Learning Program
(Covariable: Immediate Test of Learning)

Treat. ent Group	Affectivity Rating	Motivational Rating
A _g R _g	5.01	4.96
A _g R _{ng}	4.75	4.85
A _{ng} R _g	5.52	5.58
A _{ng} R _{ng}	4.82	5.03

Table B6

Adjusted Treatment Group Means for the Affectivity Ratings on the Immediate and Delayed Test
of Learning and Transfer: Immediate Test of Learning

Treat. ent Group	Immediate Test	Delayed Test
A _g R _g	.01	4.41
A _g R _{ng}	2.15	3.86
A _{ng} R _g	2.30	5.05
A _{ng} R _{ng}	2.95	4.64

Table B7

Summary of the Two-way Analysis of Covariance for the Affectivity and Motivational Ratings for the Learning Program (Covariable: Immediate Test of Learning)

Affectivity Rating				Motivational Rating			
Source	df	M/S	F	df	M/S	F	
Answer (A)	1	2.05	.90	1	4.07	1.08	
Rule (R)	1	4.62	2.05	1	2.09	.56	
A x R	1	1.22	.54	1	1.15	.31	
Error	95	2.26		95	3.76		

Table B8

Summary of the Two-way Analysis of Covariance for the Affectivity Ratings on the Immediate and Delayed Tests of Learning and Transfer
(Covariable: Immediate Test of Learning)

Immediate Test				Delayed Test			
Source	df	M/S	F	df	M/S	F	
Answer (A)	1	.01	----	1	10.40	3.45	
Rule (R)	1	2.15	.72	1	3.65	1.21	
A x R	1	2.30	.78	1	.10	.03	
Error	95	2.95		79	3.01		

APPENDIX C

SAMPLE INSTRUCTIONS AND SAMPLE OF THE PROGRAM FOR THE A R F GROUP
(ANSWER GIVEN, RULE GIVEN, FEEDBACK NOT GIVEN GROUP)

A. INSTRUCTIONS

B. PROGRAM

PLEASE BE SEATED AND READ THESE INSTRUCTIONS

This device you will be using is a teaching machine. It allows you to proceed through a "program" one step at a time. Each step is called a "frame".

When moving the program, turn the handles slowly. The paper is apt to catch at the top edge of the opening. To prevent this, please keep the paper flat with one hand as you turn the handle. If the machine jams, please call the experimenter.

This program is designed to help you get the right answers on each frame. The information you will learn is presented in small steps. Each step will explain a new concept or give an example of the concept. When taking this program, mistakes are made because of . . .

careless reading
careless copying
careless writing

Remember, READ CAREFULLY. COPY CAREFULLY. WRITE CAREFULLY.

You will be asked to complete statements or to solve problems in the program. When you see a line or a box,



write your answer in the space provided on the program sheets. You may use either a pencil or pen. Answering questions in this program will give you an opportunity to practice what you learn. Once you leave a frame and go on to the next one, you will not be able to return to it. Be sure you know the materials before going on.

This experiment will last the full period. Take as much time as you need. When you finish the program, you will be tested. Please do the best you can.

If you finish before the end of the period, please do not disturb the others. You might read or study until the end. And finally, please do not discuss the experiment with your friends.

Please wait until the experimenter gives the signal to begin the program.

HOLD PAPER HERE WHEN TURNING HANDLES

FRAME

A

PLEASE WAIT UNTIL THE EXPERIMENTER GIVES THE SIGNAL TO BEGIN THE PROGRAM

FRAME B

Please fill in the information below.

Last name

First name

Age

Grade

Period

Class

Teacher

GO TO NEXT FRAME

FRAME 1

GENERAL INSTRUCTIONS

This experiment is designed to learn how people solve problems. The problems you will learn to solve are called **ENCIPHERED SENTENCES**.

An enciphered sentence has letters that are **REARRANGED**. An example of an enciphered sentence appears below.

DEKOOL EH

GO TO NEXT FRAME

FRAME 2

An enciphered sentence can be deciphered (the letters placed in correct order) according to a rule. To decipher the sentence below, simply reverse the order of the letters. Write the last letter "H", and then the next to the last letter "E", then "L", then "O", "O", "K", "E", "D". What two words have you deciphered when you do this? Write your answer in the box.

DEKOOL EH

GO TO NEXT FRAME

FRAME 3

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When the sentence is correctly deciphered, THE WORDS AND THE SENTENCE MAKES SENSE. If the words you decipher in this experiment are not common English words, you have made a mistake.

If you deciphered "DEKOOL EH" correctly, the sentence reads "HE LOOKED".

To review, we said that an enciphered sentence is one whose letters have been

(write the correct word in the blank).

GO TO NEXT FRAME

FRAME 4

The letters of an enciphered sentence may be rearranged according to a rule.

On the line below, write the rule you can use to decipher the sentence "DEKOOL EH". Think of the steps you can follow to place the letters in correct order.

GO TO NEXT FRAME

FRAME 5

The rule you can use to decipher the sentence can be stated as simply as

REVERSE THE ORDER OF THE LETTERS.

GO TO NEXT FRAME

FRAME 6

Now decipher this sentence.

DEKLAW YEHT

GO TO NEXT FRAME

THIS IS THE END OF THE GENERAL INSTRUCTIONS

IN THE NEXT PART OF THE PROGRAM YOU WILL LEARN TO SOLVE A NEW TYPE OF ENCIPHERED SENTENCE WHICH USES A NEW RULE. DO THE BEST YOU CAN. ANSWER EVERY QUESTION. AFTER EACH FRAME, COMPARE YOUR ANSWERS WITH THE CORRECT ANSWERS GIVEN IN THE NEXT FRAME. YOU WILL BE TESTED ON THE MATERIALS YOU LEARN, SO STUDY CAREFULLY.

GO TO NEXT FRAME

FRAME 8

Please write the time it is now (hour and minute). _____

GO TO NEXT FRAME

FRAME 9

Here is a NEW PROBLEM. Let's start with something easy - just one word. A rule was used to decipher the word. Copy the deciphered word in the box.

Enciphered word: INGFLY
Deciphered word: FLYING

Here is the rule you can use to decipher this word. The rule shows the steps you can use to place the letters in correct order. Copy the rule in the space below.

PLACE THE FIRST HALF OF THE LETTERS BEHIND THE LAST HALF

GO TO NEXT FRAME

FRAME 9A

The deciphered word is: **FLYING**

The rule is: **PLACE THE FIRST HALF OF THE LETTERS BEHIND THE LAST HALF**

GO TO NEXT FRAME

FRAME 10

160

Look at this example. The rule is the same. Copy the deciphered word in the box.

VEDSER
SERVED

The rule you can use to decipher the word appears below. Fill in the blank.

PLACE THE FIRST HALF OF THE LETTERS BEHIND THE _____ HALF.

GO TO NEXT FRAME

FRAME 10A

The deciphered word is: SERVED

The rule is: PLACE THE FIRST HALF OF THE LETTERS BEHIND THE LAST HALF.

GO TO NEXT FRAME

FRAME 11

Here is another example of the same type. Only this time there are two words. Copy the deciphered words in the box.

ISHFIN ONDSEC
FINISH SECOND

The rule you can use to decipher these words appears below. Notice a step has been added that tells you how to decipher more than one group of letters. Fill in the blanks.

IN EACH GROUP OF LETTERS, PLACE THE FIRST HALF OF THE LETTERS BEHIND THE

_____ .

GO TO NEXT FRAME

FRAME 11A

The deciphered sentence is: FINISH SECOND

The rule is: IN EACH GROUP OF LETTERS, PLACE THE FIRST HALF OF THE LETTERS BEHIND THE LAST HALF.

GO TO NEXT FRAME

FRAME 12

161

This time the example is more complicated. After the letters were rearranged what simple step was done to make sense out of the letters of the first group? Copy the deciphered sentence in the box.

THESEE DOWWIN
SEE THE WINDOW

The rule that can decipher the sentence appears below. Now a step is added which tells you how to make sense out of the rearranged letters. Fill in the blanks.

IN EACH GROUP OF LETTERS, PLACE THE _____
OF THE LETTERS BEHIND THE LAST HALF. THEN SEPARATE THE LETTERS INTO WORDS.
GO TO NEXT FRAME

FRAME 12A

The deciphered sentence is: SEE THE WINDOW

The rule is: IN EACH GROUP OF LETTERS, PLACE THE FIRST HALF OF THE LETTERS
BEHIND THE LAST HALF. THEN SEPARATE THE LETTERS INTO WORDS.

GO TO NEXT FRAME

FRAME 13

Here's another example. Copy the deciphered words in the box.

SAWSHE CARTHE
SHE SAW THE CAR

GO TO NEXT FRAME

FRAME 13A

The deciphered sentence is: SHE SAW THE CAR

GO TO NEXT FRAME

FRAME 14

162

Here is the same type of example. Copy the deciphered sentence in the box.

NTTPAI ESKHED
PAINT THE DESK

Fill in the missing words in the rule below.

IN EACH GROUP OF LETTERS, PLACE THE _____

OF THE LETTERS BEHIND THE _____

THEN SEPARATE THE LETTERS INTO WORDS.

GO TO NEXT FRAME

FRAME 14A

The deciphered sentence is: PAINT THE DESK

The rule is: IN EACH GROUP OF LETTERS, PLACE THE FIRST HALF OF THE LETTERS
BEHIND THE LAST HALF. THEN SEPARATE THE LETTERS INTO WORDS.

GO TO NEXT FRAME

FRAME 15

Here is another example. Copy the deciphered words in the box.

SETCLO OORHED
CLOSE THE DOOR

GO TO NEXT FRAME

FRAME 15A

The deciphered sentence is: CLOSE THE DOOR

GO TO NEXT FRAME

FRAME 16

163

Here is an example where you must apply all of the principles you have learned.
Copy the deciphered sentence in the box.

FAITHE SCORWA FULLOR
THE FAIR WAS COLORFUL

Complete the rule that decipheres this sentence.

IN EACH GROUP OF LETTERS, PLACE THE _____

OF THE LETTERS BEHIND THE _____. THEN

_____ INTO WORDS.
GO TO NEXT FRAME

FRAME 16A

The deciphered sentence is: THE FAIR WAS COLORFUL

The rule is: IN EACH GROUP OF LETTERS, PLACE THE FIRST HALF OF THE LETTERS
BEHIND THE LAST HALF. THEN SEPARATE THE LETTERS INTO WORDS.

GO TO NEXT FRAME

FRAME 17

Please write the time it is now (hour and minute). _____

GO TO NEXT FRAME

FRAME 18

Now you have a chance to rate how you felt about the program. Indicate your
choice by placing an "x" on the line below.

1 2 3 4 5 6 7
Frustrating Enjoyable

GO TO NEXT FRAME

FRAME 19

164

If you had a choice in the matter, would you volunteer to learn other types of subject matter in the same way? Rate your willingness on the seven-point scale below.

1 2 3 4 5 6 7
Unwilling Willing

GO TO NEXT FRAME

FRAME 20

The next part of the experiment consists of a test. Attempt every problem. Please do the best you can. Some of the problems will be new to you.

Please raise your hand and the experimenter will give you a test.

Please show the experimenter this frame.

STOP - DO NOT GO ON. THIS IS THE END OF THE PROGRAM

PLEASE LEAVE THE MACHINE ON THIS FRAME - DO NOT GO ON

APPENDIX D

SAMPLE CRYPTOGRAMS AND SAMPLES OF TESTS

- A. Cryptograms used on the Examinations
 1. Cryptograms used in the Test of Learning
 2. Cryptograms used in Tests of Transfer-to-New-Examples
 3. Cryptograms used in Tests of Transfer-to-New-Transpositional Rules
 4. Cryptograms used in Tests of Transfer-to-Substitutional Rules
- B. Sample of the Problem-Solving Test
- C. Sample of the Derivation-of-Rules Test

CRYPTOGRAMS USED IN THE TEST OF LEARNING

SETCLO OORHED

FAITHE SCORWA FULLOR

SAWSHE CARTHE

CLOSE THE DOOR

THE FIAR WAS COLORFUL

SHE SAW THE CAR

CRYPTOGRAMS USED IN TESTS OF TRANSFER-TO-NEW-TRANSPOSITIONAL RULES

Form 1

USEBURNEDTHEBLUEHO
EHT STNIRP TNERA ENOD
OXESB REA ERYV SEFULU

THE BLUE HOUSE BURNED
THE PRINTS ARENT DONE
BOXES ARE VERY USEFUL

Form 2

ORSEALONELEAVETHEH
NEPO EHT TSEGRAL ROOD
HEIRT OORS D EREW HUTS

LEAVE THE HORSE ALONE
OPEN THE LARGEST DOOR
THEIR DOORS WERE SHUT

Form 3

EPIESHEREPLACETHOSE
EHT REIDLOS SAW EVARB
ILLF TSI HOLEW ENGTHL

PLACE THOSE PIES HERE
THE SOLDIER WAS BRAVE
FELL ITS WHOLE LENGTH

Form 4

VERRANDEEPTHEWIDERI
MROFNI ESOHT SYOB WON
ANGH OURY OATSC HERET

THE WIDE RIVER RAN DEEP
INFORM THOSE BOYS NOW
HANG YOUR COATS HERE

Form 5

ELONGLINEMEASURETH
EHT EGDIB SAW DENEPO
HETIRLG ASW LEEPINGS

MEASURE THE LONG LINE
THE BRIDGE WAS OPENED
THE GIRL WAS SLEEPING

CRYPTOGRAMS USED IN TESTS OF TRANSFER-TO-SUBSTITUTIONAL-RULES

Form 1

THF GUESU WAT PLEASEE
 QUICTURE UHIS NOUNTAIN
 TH5 WE19T C15AS20 IS 30012

THE GUEST WAS PLEASED
 PICTURE THIS MOUNTAIN
 THE WEST COAST IS COOL

Form 2

RETURO THF LASU PAGET
 IOWS UHEIR DONDITION
 TH9S R21LE 9S V5RY 5AS25

RETURN THE LAST PAGE
 HOWS THEIR CONDITION
 THIS RULE IS VERY EASY

Form 3

THF BOAU WAT SPEEDINH
 BNYTHING XILL IAPPEN
 PR5TT25 GI18LS 19UC3EE4

THE BOAT WAS SPEEDING
 ANYTHING WILL HAPPEN
 PRETTY GIRLS SUCCEED

Form 4

THEIS LIGHTT WENU OUU
 DOMMAND UHIS HENERAL
 PA19S T8E G12AS19 PL5AS5

THEIR LIGHTS WENT OUT
 COMMAND THIS GENERAL
 PASS THE GLASS PLEASE

Form 5

GOOE THINGT DONU LASU
 IOUSES BRE JMPORTANT
 PL5AS5 LO3K T8IS 40018

GOOD THINGS DONT LAST
 HOUSES ARE IMPORTANT
 PLEASE LOCK THIS DOOR

CRYPTOGRAMS USED IN TESTS OF TRANSFER-TO-NEW-EXAMPLES

Form 1

ORDO AS MARE OFDE ODWO
 METHEBRING ENTSPRES
 YT EP HT SI AP EG LP AE ES

DOORS ARE MADE OF WOOD
 BRING ME THE PRESENTS
 TYPE THIS PAGE PLEASE

Form 2

OCWH TAAN KL KELI ATTH
 NTTHEWHYDO HEREYEAT
 EH OS NO AS TW EH ER US TL

WHO CAN TALK LIKE THAT
 WHY DONT THEY EAT HERE
 HE SOON SAW THE RESULT

Form 3

HT NEAT WAWS OTSN ODGO
 APERWTHISP ANGEASOR
 HT SE RT AE WM SA IF LL DE

THAT NEWS WAS NOT GOOD
 THIS RAPER WAS ORANGE
 THE STREAM WAS FILLED

Form 4

AT THKE IMET OTET NKHI
 NESWETHELI OKENREBR
 HT YE EW ER EV YR OH EN TS

TAKE THE TIME TO THINK
 THE LINES WERE BROKEN
 THEY WERE VERY HONEST

Form 5

EMTH TO ISOR TGNO NGOI
 TYPTHEHEWEN REETISST
 EH AM LI DE HT TA EL TT RE

THE WATER IS NOT GOING
 HE WENT UP THE STREET
 HE MAILED THAT LETTER

Below are 12 sentences written in cipher. Please attempt to decipher each sentence. If you cannot decipher a sentence in a reasonable amount of time, go on to the next problem.

TH5 WE19T C15AS20 1s 30012

PLEASE RATE HOW YOU FELT ABOUT THIS TEST. INDICATE YOUR RATING BY
PLACING AN "X" ON THE LINE BELOW.

1 2 3 4 5 6 7

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SAMPLE OF THE DERIVATION-OF-RULES TEST

Last name

First name

Period

Below are 12 enciphered sentences and the answers. Please attempt to write the rule that decipher each example. In other words, list the steps that can be used to decipher the sentences. If you cannot find a rule for an example in a reasonable amount of time, go on to the next problem.

ENCIPHERED SENTENCEANSWER

DOMMAND UHIS HENERAL

COMMAND THIS GENERAL

1. _____

HT YE EW ER EV YR OH EN TS

THE LINES WERE BROKEN

2. _____

SETCLO OORHED

CLOSE THE DOOR

3. _____

PA19S T8E G12AS19 PL5AS5

PASS THE GLASS PLEASE

4. _____

NESWETHELI OKENREBR

THE LINES WERE BROKEN

5. _____

ANGH OURY OATSC HERET

HANG YOUR COATS THERE

6. _____

MROFNI ESOHT SYOB WON

INFORM THOSE BOYS NOW

7. _____

FAITHE SCORWA FULLOR

THE FAIR WAS COLORFUL

8. _____

AT THKE IMET OTET NKHI

TAKE THE TIME TO THINK

9. _____

DERIVATION-OF-RULES TEST (Cont.)

	<u>ENCIPHERED SENTENCE</u>	<u>ANSWER</u>
10.	VERRANDEEPTHEWIDERI	THE WIDE RIVER RAN DEEP
11.	THEIS LIGHTT WENU OUU	THEIR LIGHTS WENT OUT
12.	SAWSHE CARTHE	SHE SAW THE CAR

PLEASE WRITE THE TIME YOU FINISH THE TEST (HOUR AND MINUTE) _____

PLEASE RATE HOW YOU FELT ABOUT THE TEST. INDICATE YOUR RATING BY PLAC-
ING AN "X" ON THE LINE BELOW

1 2 3 4 5 6 7
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